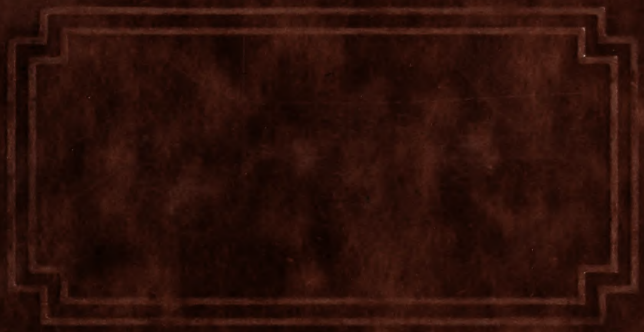

LOVELY
AM
1947
10

BOSTON UNIVERSITY
GRADUATE SCHOOL

Thesis

TOPICS SUITABLE FOR DEVELOPING UNDERSTANDINGS OF BIOLOGICAL PRINCIPLES IN SENIOR HIGH SCHOOL

by

Charles Vernon Lovely
(S.B., Bates College, 1941)

Submitted in partial fulfilment of the
requirements for the degree of
Master of Arts
July 1947

BOSTON UNIVERSITY
COLLEGE OF LIBERAL ARTS
LIBRARY

378.744
BO
AM. 1947
lo

FIRST READER Vaden W. Miles

SECOND READER Roy O. Billett

Digitized by the Internet Archive
in 2016 with funding from
Boston Library Consortium Member Libraries

https://archive.org/details/topicssuitablefo00love_0

ACKNOWLEDGMENT

The writer realizes the impossibility of adequately acknowledging all the help that has been tendered in the drawing up of this report. Thanks are due to the many who have lent aid and encouragement. There is felt a particular indebtedness to those who served as a jury to validate the work of this investigation; Eugene V. Lovely, Principal of Punchard High School, and formerly a teacher of high-school biology; Joseph B. Doherty, teacher of biology at Punchard High School; Dr. (Mrs.) Abigail K. Blake, specialist in botany, with a degree from the University of Nebraska; (Mrs.) Maxine S. Miles, formerly on the staff of the zoology department and of the medical school, University of Michigan. Further acknowledgment is made to Vaden W. Miles, of the faculty of Boston University, who directed this study.

TABLE OF CONTENTS

page

LIST OF TABLES v

CHAPTER I
SURVEY OF THE LITERATURE 1

Introduction 1
Review of Important Research Studies Pertaining to Scientific Principles as Objectives in Science Teaching 4
Survey of the Research Studies Pertaining to the Relationship of Textbook Topics to Principles ...10
Summary of the Related Literature 11
Statement of the Problem 12

CHAPTER II
THE OUTLINE OF THE SUBJECT-MATTER TOPICS FOUND IN FIVE TEXTBOOKS OF BIOLOGY 13

Statement of the Problem 13
Selection of Textbooks 13
The Formulation of a Composite Outline of Topics Related to the Biological Sciences 14
Findings 61

CHAPTER III
SUBJECT-MATTER TOPICS ALLOCATED TO BIOLOGICAL PRINCIPLES 63

Statement of the Problem 63
Technique Employed 63
Findings 107

CHAPTER IV
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS 108

Statement of the Problem 108
Method Used 108
Summary of the Findings 109
Conclusions 110
Recommendations 110

BIBLIOGRAPHY 111

APPENDIX 114

LIST OF TABLES

TABLE PAGE

I AN OUTLINE OF ALL TOPICS FOUND IN FIVE TEXTBOOKS OF BIOLOGY FOR SENIOR HIGH SCHOOL 19

TABLE

II BIOLOGICAL PRINCIPLES, AND TOPICS WHICH MAY BE USED TO DEVELOP AN UNDERSTANDING OF THEM 66

CHAPTER I

SURVEY OF THE LITERATURE

Introduction

A continuous process of change is as inherent in the school curriculum as in the living organism. Since science first began to work its way into the secondary school program it has been undergoing a perpetual metamorphosis. Changes in the science curriculum have been very often hit or miss, or even accidental, and have always been gradual. According to the Thirty-First Yearbook Committee,[1] the early programs of science in the schools were much under the influence of a psychology the fundamental concepts of which are now obsolete. The philosophy and psychology of learning have been considerably modified and modernized, however, the actual course content of the school program still retains far too many "residuals" of questionable value. This is no less true for the sciences than for the other subjects taught. In these early programs the high school cut science

[1] A Program for Teaching Science, Thirty-First Yearbook of the National Society for the Study of Education, Part I, Bloomington, Illinois: Public School Publishing Co., 1932. pp. 4-5.

into separate, specialized divisions and parcelled out these packages of organized knowledge (each supposedly complete in itself) a year at a time. The continuing influence of early theory is readily in evidence in our public schools of today.

In A Program for Teaching Science,[2] a Committee of six nationally known leaders in the field of science teaching at the secondary-school level presented in 1932 a report of the conditions of the science program as found in the public schools. The Committee also made suggestions and recommendations for improvement in the course of study in science for grades I-XIV.

It is the suggestion of the Committee that a mastery of the more important principles of science will better enable pupils to meet situations as they arise under the varying conditions encountered while in school and also after leaving school. It is, furthermore, by understanding the principles of science that the pupil may develop a clear concept of the major generalizations.[3] Downing, speaking for the Committee,[4] recommends stating the knowledge content of a course in biology in terms of important principles of biology to be mastered. He further maintains the advantage of a unified course in biology over one divided between botany and zoology, as more likely to emphasise fundamental principles.

[2] Ibid.
[3] Ibid., p. 42.
[4] Ibid., p. 223.

An interesting picture of the position of science in our schools in 1930, at approximately the time of the recommendations of the Thirty-First Yearbook Committee, can be gained from a study published by Curtis in 1932.[5] Though the schools investigated were in the North Central Association, there is no reason to believe conditions would not be comparable for similar highly selected secondary schools elsewhere in the country. It was revealed that four distinct courses of science (general science, biology, physics, and chemistry) were found in a majority of the schools studied. One or more years of science was required for graduation in all but 6.8 percent of the schools. About two-thirds of the teachers in these schools had had 12 or more hours of education courses as preparation for their position. Eighty teachers, or less than 2 percent of those reporting had had no previous subject-matter preparation in any science. Well over 80 percent of the teachers used a single textbook or a syllabus based on a single textbook. With such dubious professional preparation on the part of the teachers, and with a single textbook bearing the burden of choice and presentation of material in an overwhelming number of cases, it would seem

[5]Francis D. Curtis, "The Teaching of Science in Secondary Schools of the North Central Association," North Central Association Quarterly, VI (March, 1932), 433-474. See Francis D. Curtis, Third Digest of Investigations in the Teaching of Science, pp. 208-216. Philadelphia: The Blakiston Company, 1939.

that the setting up of a committee to study the science program and to make recommendations for the improvement of it was a highly commendable act on the part of the National Society for the Study of Education.

Review of Important Research Studies Pertaining to Scientific Principles as Objectives in Science Teaching

Though widespread interest in scientific principles as educational objectives was not manifest before the publication of the Thirty-First Yearbook in 1932, there were many who realized the importance of such objectives and some attempt had been made to determine what weight, if any, had been placed upon objectives in the current texts.

In 1927, Heinemann[6] analyzed twenty textbooks of general science to discover the attention given to principles in them. He defined a principle as "a statement of relationship between two or more facts."[7] The books he used were printed between the years 1915 and 1927, and all claimed to stem from years of work and teaching in the field of general science. Heinemann, however, decided that up to the time of his investigation no textbook of general science had been written based on principles. He recommended the writing of such a book to meet a real need.

---

[6]Ailse M. Heinemann, "A Study of General Science Textbooks," General Science Quarterly, XIII (November, 1928), 11-23.

[7]Ibid., p. 11.

After 1932 Principles and generalizations of science began to receive considerable attention and many studies were made pertaining to them. Investigators took their turn at formulating new sets of criteria for a principle and the equation for determining principles underwent a continuous evolution.

Robertson,[8] in 1934, set up the following criteria;

To be a principle, a statement:
- Must be a comprehensive generalization.
- It must be true without exception within the limitation specifically stated.
- It must be a clear statement of a process or an interaction.
- It must be capable of illustration so as to gain conviction.
- It must not be part of a larger principle.
- It must not be a definition.
- It must not deal with a specific substance or variety, or with a limited group of substances or species.

Robertson used his criteria in an investigation of 10 studies dealing with scientific principles. After subjecting these studies to a process of comparison and judgement he concluded that "There is a wide range of opinion among these elementary science experts with respect to the suitability of the various principles. . . . . There is a noticeable lack of uniformity among investigators with

---

[8]Martin L. Robertson, A Basis for the Selection of Course Content in Elementary Science, Unpublished Doctor's dissertation, University of Michigan, 1934. See Curtis, Francis D., Third Digest of Investigations in the Teaching of Science, pp. 4-5. Philadelphia: The Blakiston Company, 1939.

respect to the statement of principles."[9]

In 1935 Pruitt gave the following criteria for the determination of a principle;

A generalization:
shall be as simple, comprehensive, and definitely stated as possible.
It must be a statement of some fundamental process.
It must be true without exceptions within the limitations made in the statement.
It must be a statement capable of demonstration.
It must not be subordinate to a larger generalization.
It must not deal with specific or limited groups of substances.
It must not be a definition.

Using the above criteria, Pruitt gleaned one hundred and thirty-five generalizations of chemistry from a wide variety of sources including examinations, sociology books, newspapers and magazines, chemistry textbooks, popular books on chemistry, and 9 years' issues of the Journal of Chemical Education. He found that though "much duplication exists between content of the high school and college textbooks examined,"[11] there were significant differences in the emphasis of the texts and the emphasis of popular books of chemistry and science.

---

[9] Ibid., p. 5.

[10] Clarence Martin Pruitt, An Analysis, Evaluation, and Synthesis of Subject-Matter Concepts and Generalizations in Chemistry, Doctor's dissertation, Teacher's College, Columbia University, 1935. See Curtis, Francis D., Third Digest of Investigations in the Teaching of Science, p. 156. Philadelphia: The Blakiston Company, 1939.

[11] Ibid.

In 1941, Wise[12] made an important contribution in the determination of 264 principles of physical science most important for general education. Wise evolved the following criteria:[13]

> To be a principle, a statement must be a comprehensive generalization describing some fundamental process, constant mode of behavior, or property relating to natural phenomena.
> It must be true without exception within limitations specifically stated.
> It must be capable of illustration.
> It must not be a definition.

From these criteria he determined 165 principles classified as physics (including astronomy and meterology), 68 as chemistry, and 19 as geology. To these 252 principles 20 more were added by contributing studies to bring the total to 272. Upon submission of the list to a jury of specialists for validation, eight principles were lost, bringing the final count to 264. The principles were then arranged in descending order of their importance for general education, grades I-XIV.

---

[12]Harold E. Wise, A Determination of the Relative Importance of Principles of Physical Science for General Education, Unpublished Doctor's dissertation, University of Michigan, 1941. See Science Education, XXV, (December, 1941), 371-379; XXVI, (January 1942), 8-12; XXVII, (February, 1943), 34-40; XXVII, (September-October, 1943), 67-76.

[13]A Determination of the Relative Importance of Principles of Physical Science for General Education, Unpublished Doctor's dissertation, University of Michigan, 1941. Science Education, XXV, (December, 1941), 371-372.

Martin,[14] in 1944, did for the biological sciences what Wise had accomplished in the field of physical science. Martin again revised the criteria of a scientific principle. For a statement to be a principle:[15]

> It must be a comprehensive generalization which resumes the widest possible range of facts with which it is directly concerned. The facts resumed in the generalization must denote:
>
> a. Objects and/or events and the relations between them.
>
> b. Properties.
>
> It must be scientifically true. To satisfy this criterion:
>
> a. It must be verifiable; ie., it must be stated so that it suggests, directly or indirectly, a definite observation or experiment whereby its truth can be tested or verified.
>
> b. It must be consistent with the body of accepted scientific knowledge, and except for a few limiting or singular exceptions, with all the data (facts) relevant to it.

Martin applied the above criteria in an analysis for principles of 6 biology textbooks for high-school and junior-college levels, of reports of 5 research studies, and of a general survey series of biological science. The statements gathered as principles from the above application were submitted to three specialists in the teaching of science who evaluated each principle to determine if it was a major or minor principle. All major principles were then submitted to three specialists in the field of biology.

---

[14]Martin, W. Edgar, A Determination of the Principles of the Biological Sciences of Importance for General Education, Unpublished Doctor's dissertation, University of Michigan, 1944.

[15]Ibid., p. 50.

These specialists refined the statements of these major principles and determined the accuracy of the principles, or, generalizations.

A part of this same study by Martin16 consisted in an analysis of the materials in newspapers and magazines, including the specialized magazines Hygeia and Nature Magazine. Selected issues of these periodicals were read and analyzed for materials for the understanding of which a comprehension of one or more principles from the major or minor lists might be deemed necessary. Martin felt that what people read in magazines and newspapers should constitute a valid guide as to what subject matter should be taught in a program of general education. In all, 2620 statements or articles from the magazine and newspaper materials were assigned to 222 of the 300 major principles and to minor principles related to them.[17]

Bergman,[18] in 1946, analyzed 17 textbooks and 30 reference books of entomology, and 140 articles and research studies. He formulated 52 entomological principles and compared these to biological principles determined by others.

---

[16]W. Edgar Martin, "A Chronological Survey of Published Research Studies Relating to Biological Materials in Newspapers and Magazines", School Science and Mathematics, XLV (June, 1945), 543-550.

[17]Ibid., p. 549.

[18]George J. Bergman, "Entomology and General Education," Science Education, XXXI, (February, 1947), 23-32.

Survey of the Research Studies Pertaining to the Relationship of Textbook Topics to Principles

The only investigation of this type bearing upon the present study is that by Blanchet at the University of Michigan.[19] Blanchet made an investigation to determine the subjectmatter topics included in textbooks intended for use in survey courses in both the natural and the physical sciences at the junior-college level. The topics contained in the textbooks were considered to be the chapter, center, and paragraph headings. Working separately in the biological sciences and in the physical sciences, Blanchet first made an outline of the topics contained in each book and then these outlines were consolidated into an outline including topics from all books. This resulted in two topical outlines, one for the physical sciences, the other for the biological sciences.

In the second phase of the investigation by Blanchet, the major topics (those of primary or secondary importance) from the two composite outlines were allocated to the principles of physical and biological science as listed by Wise and Martin, respectively. Whenever, in Blanchet's opinion, a discussion of a topic might be reasonably expected to include materials which would contribute to

---

[19]Waldo Emerson Blanchet, A Basis for the Selection of Course Content for Survey Courses in the Natural Sciences, Unpublished Doctor's dissertation, University of Michigan, 1946.

developing an understanding of a principle, the topic was assigned to that principle.

Blanchet found that the contents of textbooks, in spite of their diversity, do include materials suitable for developing understandings of principles, although they, as and of themselves, may not accomplish this objective.[20]

Summary of the Related Literature

The importance of principles, or generalizations, of science as objectives in science teaching has long been recognized. The bulk of the work pertaining to them, however, has been done since the publication of the Thirty-First Yearbook of the National Society of Education. Studies have been carried on independently at several different institutions; at Columbia University, Teacher's College, under S. Ralph Powers and Gerald S. Craig; at the University of Chicago, under the late Elliot R. Downing; and at the University of Michigan under Francis D. Curtis. More recently studies have also been made at New York University under the direction of Charles J. Pieper and Martin L. Robertson, and at Boston University under Vaden W. Miles.

---

[20] Ibid., p. 307.

Statement of the Problem

The purpose of the investigation is (1) to compile a composite outline of the subject-matter topics found in five textbooks of biology for high school, and (2) to assign to biological principles those topics which a study of should contribute to the development of an understanding of the principles.

CHAPTER II

THE OUTLINE OF THE SUBJECT-MATTER TOPICS FOUND IN FIVE TEXTBOOKS OF BIOLOGY

Statement of the Problem

The purpose of this part of the investigation is to compile a composite outline of the subject-matter topics found in five textbooks of biology for high school.

Selection of Textbooks

The criteria for the selection of textbooks for analysis in this investigation for subject-matter topics were: The textbook (1) must have been published or revised since 1940, and (2) must have been produced by well-known publishing houses which serve all regions of the United States. The following five books were found to meet these criteria, and were used in this investigation:

Biology for Better Living, Bayles and Burnett, Silver Burdett Company, New York City, 1941.

Biology and Man, Gruenberg and Bingham, Ginn and Company, Boston, 1944.

Biology and Human Affairs, Ritchie, World Book Company, Yonkers, New York, 1941.

Biology for You, Vance and Miller, J.B. Lippincott Company, Chicago, 1946.

Life Science, Benedict, Knox, Stone, The Macmillan Company, New York City, 1941.

The Formulation of a Composite Outline of Topics Related to the Biological Sciences

In order to formulate a topical outline for the five textbooks, an outline was first made for each textbook. The subject-matter topics were selected in accordance with the criteria used by Blanchet, namely, the chapter, center, and paragraph headings of each book.[1] Upon inspection of the five outlines thus formulated, the following major divisions of the biological sciences included in the textbooks became apparent: Science of biology - living things; Uses of biology; Springtime biology; Adaptations and interrelations of life; Conflicts of life; Plants and plant activities; The soil and conservation; Mechanics of biology; Reproduction and heredity; Body systems and functions; Food getting and excretion; Behaviour, sensitivity and response; Health and sickness; Classification.

The organization of the composite table of topics was accomplished by fitting together the various subtopics from the different textbooks which fell under the same major division. The book which had the largest number of subtopics in the major division under consideration was used first as a basis on which to build. In each case a sheet

---

[1]Blanchet, W.E., A Basis for the Selection of Course Content for Survey Courses in the Natural Sciences, p. 183. Unpublished Doctor's dissertaion, University of Michigan, 1946.

of paper was ruled with six vertical columns at the right; one column was used for each of the five books and the sixth was used for the total number of books in which a topic appeared. A code letter was assigned to each book, and at the top of each column at the right of the page the code letter for each book was placed. The topics from the pertinent major division of the text with the largest number of subtopics under this division (for example, text B) were then written in outline form at the left-hand side of the paper. An (x) was then placed opposite each topic in the appropriate column headed by the code letter (B) used to designate the book. The book with the next largest number of topics (for example, text D) was then used and topics from the outline of this second text were added to the topical outline of the first text. This was done by first placing an (x) in column (D) opposite each topic in the second text which had already been entered from the first text (B); then, when all the topics which the two texts had in common had been checked under the column (D), for the second text, the remaining topics from the second book were added at appropriate places to the outline and were checked in column (D).

The same procedure was followed for the remaining texts, and for the remaining major divisions.

When topics were found that were worded differently but carried the same meaning, the topic which seemed the more appropriate was used. It was found in many cases that the

topics as worded in a textbook were not clear. In all such cases the investigator paraphased the wording of the textbook in order to achieve clarity.

When all the topics contained in the five textbooks had been combined according to the procedure outlined above, the composite outline was checked against the textbooks themselves in order to assure that no topic from any text had been lost in the procedure, or that no text had been credited with a topic which it did not definitely contain.

Three copies of the outline were then made and submitted to three subject-matter specialists.* In accordance with the procedure used by Blanchet,[2] these specialists were asked to examine the outline with care to be certain that the position of each topic in the outline was defensible, and that even though it might be differently worded, no topic appeared more than once, unless the differences in its inferred or implied significance at the two or more points in the outline clearly demanded that it be treated as two or more separate topics.

---

*Eugene V. Lovely, Principal of Punchard High School, formerly teacher of high-school biology; Joseph B. Doherty, teacher of biology at Punchard High School; Dr. (Mrs.) Abigail K. Blake, specialist in botany, with a degree from the University of Nebraska.

[2]Ibid., p. 189

If it was the suggestion of any specialist that a topic be transferred from one position in the outline to another, that suggestion was followed unless the topic appeared in the same spot in the composite outline as in the outline of the text from which it came. If two or more specialists suggested a change, it was made, providing they agreed upon the point to which it should be transferred.

The frequency of appearance of subject-matter topics was determined as the sum of the checks (x) opposite each item in the composite outline.

In all cases where a minor topic was contained in a textbook but the major topic was not found, both the major and minor topics are checked. This insured that minor topics did not gain a greater composite value than the major topics to which they are subordinate. This procedure is justified because of the defensibility of the placements of the topics in the composite outline.

The following key designates the code letters used for the textbooks in Table I.

Code Letter	Author or authors and title
A.	Bayles and Burnett, Biology for Better Living
B.	Gruenberg and Bingham, Biology and Man
C.	Ritchie, Biology and Human Affairs

Code Letter	Author or authors and title
D.	Vance and Miller, Biology for You
E.	Benedict, Knox, Stone, Life Science

The final composite outline is presented in Table I, which follows.

TABLE I

AN OUTLINE OF ALL TOPICS FOUND IN FIVE TEXTBOOKS OF BIOLOGY FOR SENIOR HIGH SCHOOL

TOPICS	BOOKS					
	A	B	C	D	E	T*
Science of biology - living things	x	x	x	x	x	5
Biology - study of life	x	x	x	x	x	5
What biology is	x					1
Life is everywhere		x				1
Kinds of biology		x		x		2
Magic science and man	x		x			2
How did magic arise?	x					1
Evil spirits released through holes in living skulls	x					1
The Delphian oracle	x					1
Can reliable information be discovered by pure reason?	x					1
Vesalius, stealer of skeletons	x					1
Limitations of observation as a method of discovering information	x					1
Beaumont and St. Martin's wound	x					1
Beaumont performs an important experiment	x					1
Witchcraft			x			1
Astrology			x			1
Science destroys evil and superstition			x			1
A safeguard against misleading propaganda			x			1
Biology and health			x			1
Knowledge gains control of disease			x			1
Biology and the food supply	x		x			2
Liebig discovers fertilizer	x					1
Other ways of increasing the food supply	x					1
Preservation of food	x					1
Biology and society			x			1
Law of normal variation			x			1
Biology and a world of differences			x			1
Biology and everyday life				x	x	2
Biology helps to solve problems	x			x		2
Reasons for study of biology		x		x		2
Biology, industry, and everyday life				x		1
The microcosm				x		1

*Total

**Table I is read thus: The topic "Science of Biology, living things" was found in each of the five textbooks analyzed.

TABLE I (CONTINUED)

TOPICS	BOOKS					
	A	B	C	D	E	T
Recent discoveries in biology			x			1
Biology and the public domain			x			1
Constancy of the living world			x			1
Mental adjustment to world necessary			x			1
Biology helps in adjustment problems			x			1
Biology aids in satisfying instinctive desires			x			1
Harmony with our instinctive nature necessary			x			1
Biology gives contact with living things			x			1
Biology and the Constitution of the U.S.			x			1
Purposes of the founders			x			1
Protection against governmental tyranny			x			1
Protection against majorities			x			1
The Bill of Rights			x			1
What is life?	x	x			x	3
How plants and animals are alike		x				1
The parts of plants		x				1
The human body		x				1
An insect		x				1
Comparison - similar structures		x				1
Animal activities		x				1
Organisms		x				1
Differences in living and non-living things	x	x				2
Growth		x				1
Irritability		x				1
Fitness		x				1
Origin		x				1
Adaptation		x				1
Reproduction	x					1
The functions of life	x					1
Living things					x	1
Forms					x	1
Largest living things					x	1
Smallest living things					x	1
Kinds					x	1
of animals					x	1
of plants					x	1
Habitats					x	1
The ocean					x	1
Fresh water					x	1
Arctic regions					x	1
Temperate regions					x	1
Tropical regions					x	1
Deserts					x	1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Builders of biology			x		x	2
Aristotle			x			1
Pioneers with lenses					x	1
DeVries			x			1
Galton			x			1
Thorndike			x			1
Fabre			x			1
Science-to obtain and test knowledge	x	x	x	x		4
Importance of facts			x			1
Man the creator		x				1
Science disarranges things		x				1
Obstacles to progress		x				1
The cost of improvement		x				1
Science is objective		x				1
Scientific method	x		x	x		3
Examples of scientific method			x			1
The scientific mind	x		x			2
Cause and effect				x		1
Experimentation	x					1
The spirit of science	x		x			2
In what fields of human activity can science offer help?	x					1
Why science advances			x			1
Scientific method in a changing world			x			1
A glimpse ahead			x			1
Immutable laws of physical nature			x			1
Fact and theory in science			x			1
Uses of biology				x		1
Pleasure and profit from biology				x		1
Luther Burbank				x		1
The Burbank potato				x		1
Off to California				x		1
New creations in plant life				x		1
Biological training important to fruit and vegetable growers				x		1
Propagation by grafting				x		1
Tongue or whip grafting				x		1
In arch grafting				x		1
Root grafting				x		1
When to graft				x		1
Uses of grafting				x		1
Budding				x		1
Seedless oranges				x		1
Treatment of tree bark injuries				x		1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
How and when to prune trees				x		1
How decayed spots in trees may be treated				x		1
Bracing trees				x		1
Attracting birds				x		1
Window gardens				x		1
Beautiful lawns				x		1
Good slope and drainage important				x		1
Good soil needed				x		1
How to sow grass seed				x		1
Sodding a lawn				x		1
Rolling established lawns				x		1
Feed the lawn occasionally				x		1
How often to mow a lawn				x		1
Watering				x		1
Getting rid of weeds				x		1
Grasses under trees				x		1
Lawn pests				x		1
Evergreens and flowering shrubs				x		1
Planning and planting offer worth-while Jobs				x		1
Rock gardens for steep terraces				x		1
A garden pool				x		1
The vegetable garden				x		1
Selecting the seed				x		1
Make a plan ahead of planting				x		1
Choose the location carefully				x		1
Prepare the seed bed carefully				x		1
Setting out plants				x		1
Cultivation				x		1
Watering				x		1
Pest and disease - protection				x		1
Harvesting and storage				x		1
Biology a preparation for vocations				x		1
Doctor				x		1
Dentist				x		1
Nurse				x		1
Farmer				x		1
Forester				x		1
Museum curator				x		1
Other vocations				x		1
Biological work in general				x		1
Springtime biology			x			1
Bird activities			x			1
Migration			x			1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
How birds find their way			x			1
Why birds migrate			x			1
Mating			x			1
Building the nest			x			1
Bird language			x			1
Water activities			x			1
Frogs			x			1
Eggs and early development			x			1
Metamorphosis			x			1
The garden toad			x			1
The crayfish			x			1
Body			x			1
Appendages and movement			x			1
Life			x			1
Reproduction			x			1
Equilibrium			x			1
Internal organs			x			1
Behavior			x			1
Mussel or fresh water clam			x			1
How the mussel lives			x			1
Early life			x			1
Uses			x			1
Study of mussels			x			1
Relatives of the crayfish and the mussel			x			1
Insects of spring			x			1
Ways of passing the winter			x			1
Butterflies and moths			x			1
The cabbage butterfly			x			1
Moths			x			1
The dragonfly			x			1
Features			x			1
Life history			x			1
Insects that hibernate			x			1
Freshwater plants of springtime			x			1
Structure of a diatom			x			1
Diatom distribution			x			1
Importance of diatoms			x			1
Spring flowers			x			1
The great groups of flowering plants			x			1
Procedure in classification			x			1
Spring monocots			x			1
Polypetalous families			x			1
Sympetalous			x			1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	Tl
The changing year			x			1
Adaptations and interrelations of life	x	x	x	x	x	5
Adaptations for protection	x	x	x			3
Plant adjustments to changing water supply		x	x			2
Seasonal change, plant		x	x			2
Animals in winter		x				1
Animals in dry seasons		x				1
Life in a tide pool		x				1
Healing and regeneration		x				1
Growth substances		x				1
Poisons		x				1
Getting used to changed conditions		x				1
Habit forming poisons		x				1
Antitoxins		x				1
Modified protoplasm		x				1
Protoplasm strikes back		x				1
Plant protection against animals			x			1
Protective devices (skulls, spines, quills)	x		x			2
Protective coloration	x		x			2
Sloth			x			1
Mimicry	x		x			2
Animal shells			x			1
Traveler's palm-protection against drought			x			1
Oxygen storage, whales and penguins			x			1
Adaptations for speed	x					1
How the rabbit protects himself	x					1
Other animals adapted for flight	x					1
Protection by fighting	x					1
Mutually helpful adaptations coexistant	x					1
Versatility of the human hand	x					1
Versatile adaptations need conscious direction	x					1
Developing adaptations, nature's problem	x					1
Adaptation of leaves for changing conditions			x			1
Protection of seeds from animals			x			1
Interdependence of life		x	x	x	x	4
Life and light		x				1
The food cycle		x				1
Natural groupings of organisms		x				1
Life on the march		x				1
Barriers to migration		x				1
Types of communities - swamp, grass, etc.		x				1
First settlers- pioneering plants		x				1
Changing population		x				1
Climax community		x				1

TABLE I (CONTINUED)

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Moving equilibrium			x			1
Symbiosis		x	x	x	x	4
Parasitism and symbiosis			x			1
Other examples of associate living			x			1
Nutritional relationships of living things			x			1
Adaptation of "non-green" plants to the getting of food	x		x		x	3
Plants grouped by food getting habits	x					1
Manufacture of food by bacteria	x					1
Parasitism, bacteria and other fungi	x		x		x	3
Obligate and facultative parasites			x			1
Well adapted and ill adapted parasites			x			1
Restricted life of parasites			x			1
Economic losses from parasitic organisms	x					1
Saprophytes obtain food	x		x		x	3
Decay and its cause	x				x	2
Molds obtain food	x				x	2
Toadstools and mushrooms obtain food	x				x	2
Control of plant diseases	x					1
Food getting among plants without chlorophyll	x					1
What are carnivorous plants?	x		x		x	3
Scarciry of nitrogen and adaptations	x					1
Pitcher plant	x					1
Venus' fly trap	x					1
Plant adaptations as varied as animals'	x					1
Conflicts of life		x				1
Struggle for existence		x				1
Passive struggle in plants		x				1
How plants compete		x				1
Pure chance in the life of the plant		x				1
Struggle patterns		x				1
Struggle and competition		x				1
Plants sensitive and active		x				1
Meaning of fitness		x				1
What all species need		x				1
Life in water or on land- specialization		x				1
Adaptation to changes		x				1
Intensification of life		x				1
Sensitiveness		x				1
Man and other animals		x				1
Fighting drives		x				1
Man as a social organism		x				1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Men must fight		x				1
The moral equivalent of war		x				1
Limitations of life		x				1
Life self limiting		x				1
Life is a pattern		x				1
What causes death?		x				1
Division of labor		x				1
Advantages of specialization		x				1
Disadvantages of specialization		x				1
Balanced functions		x				1
Limitations inthe environment		x				1
Life and death cycle		x				1
Distribution of life		x				1
Distribution automatic		x				1
Hinderances to human life		x				1
Man and his relationships		x	x	x	x	4
What living things most like men?		x				1
Basis for comparison		x				1
Other mammals		x				1
How man differs from other primates		x	x	x		3
Hands and feet		x				1
Enlarged brain		x				1
Chin and mouth		x				1
Speech		x				1
Man's shortcomings		x				1
Man and apes		x				1
What is unique about man?		x				1
Man's advantages		x				1
Tools, weapons, shelter		x				1
Fire		x				1
Sociality		x				1
How is man more than animal		x				1
Preservation of experience- art, literature		x				1
Imagination and abstraction		x				1
Creativity		x				1
More than beast		x				1
Man an interloper		x				1
Man the wanderer		x				1
Human communities		x				1
Interdependence of men		x				1
Limitations of self sufficiency		x				1
Likeness of man to other living things		x		x		2
Human physical traits			x		x	2
Hair texture					x	1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Head form					x	1
Skin color					x	1
Structure and other traits					x	1
Types of culture					x	1
Stages of culture					x	1
Environment and culture					x	1
Plants and animals useful to man					x	1
Food plants					x	1
Plants in industry					x	1
Other uses of plants					x	1
Uses of mammals					x	1
Other animals and animal products					x	1
Man's control of other species					x	1
Fungi, weeds, insects, birds, mammals					x	1
Social traits of man			x			1
Individual social relationships			x			1
Loyalty of individual to group			x			1
Relationship between groups			x			1
Fundamental trait			x			1
Human society necessarily imperfect			x			1
Morality of the human group			x			1
Human progress, the rise of man					x	1
The story of human development					x	1
Pieced together by scientists					x	1
Man's development traced by tools					x	1
Species and genera of man					x	1
Distribution					x	1
Earliest species					x	1
The biological basis of human progress					x	1
Man differs from other social animals					x	1
Discoveries have led to human progress					x	1
Plants and plant activities	x	x	x	x	x	5
Photosynthesis	x	x	x	x	x	5
Raw materials needed in food manufacture	x					1
Sunlight	x	x	x	x	x	5
Chlorophyll	x	x	x	x	x	5
Carbon and water					x	1
Photosynthesis in stems	x					1
Importance of plant life	x	x	x			3
Manufacture of oxygen in photosynthesis	x			x	x	3
Leaves as starch factories	x	x	x	x	x	5
Green leaf a community of specialized cells	x					1
Adaptation of leaf for its work			x			1
Structure of the leaf	x		x	x	x	4
Margin, inside and outside				x		1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	Tl
Chemical changes in food manufacture	x					1
Conditions necessary for photosynthesis	x					1
Plants especially adapted to food making	x					1
Experiment with starch formation in leaves				x		1
Importance of green algae in fresh water			x			1
Primary food building processes			x			1
Secondary food building processes			x			1
Historical notes	x					1
Ancients thought of earth as huge "stomach"	x					1
Van Helmont and his willow twig	x					1
Later experiments and what they have shown	x					1
Plant nutrition	x	x	x	x	x	5
Plants manufacture and use food	x	x			x	3
Production of proteins	x		x		x	3
Water					x	1
Minerals					x	1
Production of fats from carbohydrates			x		x	2
Protein synthesis					x	1
Physical characteristics					x	1
Chemical structure					x	1
Plant leaves as food				x		1
Leaves with special functions				x		1
Plants without chlorophyll (albinos)				x		1
Synthetic sugar and the chemist				x		1
Transpiration	x	x	x	x	x	5
Respiration in simple plants					x	1
Respiration in green plants					x	1
Digestion of starch in plant cells		x			x	2
Digestion in green plants					x	1
Motion in plant protoplasm					x	1
A comparison of photosynthesis and respiration	x			x		2
Growth in plants	x		x	x	x	4
Tissue development			x			1
Growth of woody stems	x		x	x		3
How dicots grow	x			x		2
How monocots grow	x			x		2
Quartersawed wood				x		1
Tree rings				x		1
Bark				x		1
Pith				x		1
Bud growth shapes the plant				x		1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Leaf arrangement				x	x	2
Development of new organs					x	1
Plant structure and stems	x	x	x	x	x	5
Principal plant tissues	x	x	x	x	x	5
Epidermis			x			1
Sclerenchyma			x			1
Vascular tissues		x	x			2
Structure of a bundle	x		x	x		3
Xylem	x			x		2
Phloem	x	x				2
Water vessels			x			1
Food vessels - sieve tubes			x			1
Types of stems		x				1
Plant stems in industry				x		1
Herbaceous stems			x			1
Major function of stems, circulation	x	x		x	x	4
Sap does not truly circulate	x					1
Factors causing water and salts to rise in stems	x	x		x	x	4
Root pressure				x		1
Evaporation pull				x		1
Phloem - two way road	x					1
Girdling kills trees	x					1
Characteristics of dicot and monocot stems			x			1
The monocot bundle			x			1
The dicot stem			x			1
Other major functions of the stem	x		x	x	x	4
Propagation	x					1
Support			x			1
Storage, tubers				x		1
Water relations of higher plants			x			1
The plant world			x			1
Plant roots	x	x	x	x	x	5
The work of the root		x	x			2
Types of roots and root systems	x		x	x		3
Sized of root systems	x		x	x		3
Structure of root	x		x	x	x	4
Root hairs	x					1
Water and salts enter living cells of root	x		x	x	x	4
Other functions of root	x		x			2
Storage, reproduction, anchorage	x		x			2
Roots adapted to different environments			x			1
Root growth and movement				x		1
Root cap				x		1
Medicinal roots				x		1

TABLE I (CO TINUED)

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Unusual root growth				x		1
Hydroponics				x		1
Weeds, nuisance plants	x			x		2
Sometimes a weed, sometimes not				x		1
What makes a plant a weed?	x			x		2
Weeds useful as well as harmful				x		1
Weeds adapted to environment				x		1
Three plant groups - annuals, biennials, perennials				x		1
Some common weeds				x		1
Some weeds poisonous				x		1
Nuisance weeds				x		1
Weed control	x			x		2
Watering bluegrass lawns	x					1
Seeds in industry				x		1
Soybean				x		1
Peanuts				x		1
Corn				x		1
Others				x		1
Bacteriology			x	x		2
Bacteria			x	x		2
Characteristics and culture				x		1
Where they come from				x		1
Size				x		1
Culture				x		1
Relationships			x	x		2
Reproduction				x		1
Surviving unfavorable conditions				x		1
Movement				x		1
Classification				x		1
Preservation of foods				x		1
Pasturization				x		1
Other protections from bacterial spoilage				x		1
Useful bacteria				x		1
Aerobic bacteria in the soil				x		1
Nitrogen fixing bacteria				x		1
The soil and conservation	x	x	x	x	x	5
Formation and composition of the soil	x	x	x	x		4
Life multiplies and soil forming speeds up	x					1
The growth of a world	x					1
Life begins	x					1
What soil is	x		x			2
Minerals	x					1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Humus	x					1
Living creatures in the soil	x					1
Water in the soil	x		x			2
Air in the soil	x					1
Elements necessary for plant life	x		x			2
Properties of good soil	x		x			2
Sufficient water	x					1
Available minerals	x					1
Stabalized topsoil	x					1
Improving soil through the use of manures			x			1
Acidity and alkalinity			x			1
Some land unfit for crops, should be retired	x					1
Conditions governing life of a plant				x		1
Temperature				x		1
Altitude				x		1
Moisture				x		1
Plants far from native home				x		1
Plant social groups				x		1
Plant succession				x		1
Man changes natural succession				x		1
The soil and the life it sustains		x				1
Soil Conservation	x	x	x	x	x	5
A dramatic warning	x					1
The earth rises, dust storms	x			x		2
The dust bowl				x		1
Reclamation by irrigation				x		1
Are dust storms entirely new?	x					1
Undermining America, destroying the land	x	x				2
Whose problem is this in our democracy?	x					1
What cause of destruction of our land	x					1
The limitless frontier	x					1
Clear the forests for timber and land	x					1
America, breadbasket of Europe	x					1
Industrial revolution reaches the farm	x					1
American farmer, rugged individualist	x					1
Where does America stand now?	x					1
Americans all	x					1
Present farming practices ruin much land	x					1
Conservation needs cooperation of all	x					1
The nitrogen problem	x	x	x		x	4
Nitrogen fixing bacteria and legumes	x		x			2
Cowpeas and soybeans	x					1
Alfalfa	x					1
Sweet and red clover	x					1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	Tl
Rotation of crops	x	x		x		3
Industrial fixation of nitrogen		x				1
Necessity for conservation	x					1
Basic needs		x				1
Human needs		x				1
National planning to save the soil	x		x			2
Soil conservation service experiment	x					1
Grasses hold soil and moisture	x		x			2
Contour farming	x					1
Strip cropping	x					1
Terracing	x					1
Gully control	x					1
Other conservation practices	x					1
Soil conservation as a vocation	x					1
Forest conservation	x	x		x	x	4
Poor handling of timber resources	x			x		2
Mining of wood		x		x		2
What our lumber is used for				x		1
Right handling of timber		x		x		2
Avoiding wood waste		x				1
Cropping rather than mining		x		x		2
Forest dangers		x		x		2
Future forests				x		1
Forest fires				x		1
The soil's fertility		x				1
Earth and water		x				1
The forest and water		x			x	2
Water power		x			x	2
Projects for saving forests	x	x		x		3
The C.C.C. and forests	x					1
Forest service		x				1
Planning and planting				x		1
Forestation, or forest extension				x		1
Our great national forests				x		1
An Ohio flood				x		1
Destruction of the land				x		1
The crystal clear streams of pioneer days				x		1
Destructive pioneer man				x		1
Erosion				x		1
Soil control - it can be done				x		1
Importance of soil conservationist's work				x		1
Soil minerals				x		1
Soil deficiencies				x		1
Methods of control				x		1
Everyone who uses the land can help				x		1
Immediate benefit for the farmer				x		1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Cooperation needed				x		1
School conservation projects				x		1
Control of pests	x	x	x			3
Measures used to control insects	x		x			2
Predatory insects			x			1
Birds and other natural checks	x		x			2
Dusting and spraying	x		x			2
Control of biting insects	x					1
Control of sucking insects	x					1
Control of sucking insects on animals	x					1
Control of insects attacking poultry	x					1
Other methods of insect control			x			1
Control of pests that attack sheep	x					1
Importance of the insect problem	x		x			2
Hand to hand fighting		x				1
Barriers		x				1
Epidemic and counter epidemic		x				1
Preventing the growth of fungi	x					1
Controlling fungi	x					1
Smuts, rusts, mildews, molds	x					1
Complete extermination of Mediterranian fruit fly in U.S.	x					1
Natural immunity to pests	x					1
National pest control	x					1
Wildlife conservation	x	x		x	x	4
The conservation idea		x				1
Conservation of natural beauty					x	1
The intrusion of man		x				1
Game laws in effect	x	x		x		3
Migratory bird laws	x	x				2
Fedral regulation of killing game animals	x					1
State game laws	x					1
Laws relating to fur bearing animals	x					1
Other factors in conserving game				x		1
Major features of national conservation program	x					1
State conservation programs	x					1
Missouri program	x					1
Fishing laws and regulations	x					1
What wild amimals need our help?	x					1
What kinds of wild life should be saved?	x					1
Wild life refuges	x					1
Why protect some animals and not others?	x					1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Time of year for closed seasons	x					1
The balance of life		x		x		2
Life always upsetting		x				1
Food and elbow room		x				1
Epidemics		x				1
Extinction of wild animals				x		1
Man and birds		x				1
Destruction of birds		x				1
Migration		x				1
Transportation		x				1
Increasing the number of young brought to maturity	x					1
Increasing the supply of wild life	x					1
National wildlife conservation associations	x					1
Man not entirely responsible for situation				x		1
Wild life belongs to us all				x		1
Stream polution				x		1
Other ways in which fish are destroyed				x		1
Conservation of fish and other water animals				x		1
Making studies of resources				x		1
Value of water animals as food				x		1
Man power and conservation of humanity		x				1
Sources of new power		x				1
Mechanics of biology	x	x	x	x	x	5
Biological chemistry and physics	x	x	x	x	x	5
What matter is			x			1
Atoms and molecules			x			1
The motion of molecules					x	1
Chemical symbols and formulae			x			1
Definition of element and compound			x			1
Forming a compound from elements			x			1
Breaking a compound into its elements			x			1
Chemical and physical changes			x			1
Causes of chemical action in living things			x			1
Law of conservation of matter			x			1
Conservation of matter in living world			x			1
What energy is			x			1
Transformation and conservation of energy			x			1
Storage of energy			x			1
Aquisition of energy			x			1
Oxidation			x			1
Diffusion	x	x		x	x	4
Through membranes				x		1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Among cells of our bodies				x		1
Some substances don't diffuse readily				x		1
Osmosis	x	x	x	x	x	5
Osmotic pressure				x		1
How materials enter cells		x		x		2
An organism as a chemical mechanism			x			1
Organic molecules			x			1
Carbon cycle		x			x	2
Oxygen cycle		x			x	2
The cell and cell theory	x	x	x	x	x	5
Variety of cells	x	x		x	x	4
Nucleus		x	x	x		3
Form and parts of the cell			x	x	x	3
Differences in plant and animal cells			x			1
One celled plants and animals			x			1
Meaning of the word cell			x	x	x	3
All living things made up of cells	x		x	x		3
Multiplication of cells		x		x	x	3
Nuclear division		x		x	x	3
Mitosis				x	x	2
Reduction division				x		1
A look into microscopes				x	x	2
Early microscopes				x		1
Modern microscopes				x		1
The electron microscope				x		1
Use of the microscope				x		1
Cleaning the instrument				x		1
Cleaning slide and cover glass				x		1
General directions for microscope mounts				x		1
Early ideas about cells					x	1
How to see and study living cells				x		1
Green leaf cells				x		1
Animal cells (corpuscles) in a blood smear				x		1
How living cells do their work				x		1
Cells usually do not serve alone				x		1
What living cells can do				x		1
Cell activities				x		1
Characteristics of plant cells			x			1
Protoplasm	x	x	x	x	x	5
Composition of protoplasm			x		x	2
Physical and chemical					x	1
Protoplasm fundamental		x				1
A chemical maching		x				1
How water acts in protoplasm		x				1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Water and sprouting of seeds		x				1
Variations in protoplasm		x				1
Unity of a living organism		x	x	x	x	4
Anatomizing- organs, tissues, cells		x	x		x	3
Living fragments, chicken heart		x				1
Wholes before parts		x				1
Hormones and nerves as unifiers		x		x		2
The plant as a whole			x			1
Relation of circulation to bodily function				x		1
Larger plants and animals colonies of cells			x			1
Reproduction and heredity	x	x	x	x	x	5
Reproduction	x	x	x	x	x	5
The Phoenix				x		1
Continuity of life		x	x			2
Regeneration and vegetative reproduction	x	x	x		x	4
Regeneration in animals					x	1
In plants					x	1
Reproduction by regeneration					x	1
Artificial vegetative reproduction	x		x		x	3
Advantages and disadvantages of vegetative reproduction			x			1
Spores and cysts	x	x	x	x	x	5
Origin of bacterial colonies	x					1
In molds	x		x			2
In spirogyra			x	x		2
Definitions of gamete, spore, reproduction			x			1
Reproduction in blue green algae			x			1
Gleocapsa, oscillatoria, nostoc			x			1
Green algae			x			1
Desmids, ulothrix			x			1
Zoospores			x			1
Economic importance of green algae			x			1
Fertilization of the egg		x	x			2
Spontaneous generation disproved		x	x	x	x	4
Asexual reproduction	x		x	x	x	4
Fission	x				x	2
Budding	x		x		x	3
Sexual reproduction	x	x	x	x	x	5
In simple organisms			x	x	x	3
In higher plants				x		1
In higher animals			x	x		2
Gametes		x	x		x	3
Increasing complexity, water to land		x	x			2
Primary sex characteristics		x				1
Secondary sex characteristics		x				1
Hermophrodites	x					1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Parthenogenesis			x		x	2
Reproduction in ferns		x				1
Alternation of generations		x				1
Life history of the moss		x				1
Reproduction in coelenterates		x			x	2
In aquatic invertebrates		x				1
In worms					x	1
Amoungst insects		x			x	2
Vertebrate reproduction		x	x		x	3
Aquatic vertebrates and amphibians		x			x	2
Reptiles and birds			x		x	2
Mammals		x			x	2
Food supply for the embryo			x			1
Flowers, reproduction in higher plants	x	x	x	x	x	5
Flower clusters				x		1
Parts and function of typical flower	x	x	x	x	x	5
Accessory organs		x			x	2
Ovule and egg	x	x			x	3
Anther and pollen	x	x			x	3
Flowers as secondary sexual structures		x	x			2
Fertilization in a flower	x	x	x	x	x	5
The new individual		x				1
Self-pollenation and obstacles to it		x		x		2
Cross pollenation	x	x	x	x	x	5
Agents of pollenation	x			x		2
Artificial pollenation				x		1
Popcorn among sweet corn				x		1
Cross pollenation of fruit trees				x		1
Dry pollen may live two years or more				x		1
Seeds and the species		x	x	x		3
From generation to generation		x				1
Seed development				x	x	2
Pollen reaches the stigma				x	x	2
Subsequent processes				x	x	2
Pollenation of yucca and fig				x		1
Bees and pollenation				x		1
Structure of seeds and fruit			x	x		2
Fruits ripened ovaries				x		1
Varying structure and appearance of fruit				x		1
How seeds are made				x		1
Food may be stored outside cotyledons				x		1
Structure of corn grain				x		1
Changes in a sprouting grain				x		1
Stored seed foods insoluable in water				x		1
Other foods in seeds				x		1

TABLE I (CONTINUED)

TOPIC	A	B	C	D	E	F
Parthenogenesis			x		x	2
Reproduction in ferns			x			1
Alternation of generations			x			1
Life history of the moss			x			1
Reproduction in coelenterates			x		x	2
In annelid invertebrates			x			1
In worms					x	1
Amphibian insects			x		x	2
Vertebrate reproduction			x	x	x	3
Aquatic vertebrates and as children			x		x	2
Reptiles and birds				x	x	2
Mammals			x		x	2
Food supply for the embryo			x			1
Flowers. reproduction in higher plants	x	x	x	x	x	5
Flower clusters		x				1
Parts and function of typical flower	x	x	x	x	x	5
Accessory organs			x		x	2
Ovule and egg			x	x	x	3
Anther and pollen			x	x	x	3
Flowers as secondary sexual structures			x			2
Fertilization in a flower	x	x	x	x	x	5
The new individual			x			1
Self-pollination and obstacles to it		x		x		2
Cross pollination	x	x	x	x	x	5
Agents of pollination			x		x	2
Artificial pollination			x			1
Poppies among sweet corn			x			1
Cross pollination of fruit trees			x			1
Dry pollen may live two years or more			x			1
Seeds and the species			x	x	x	3
From generation to generation			x			1
Seed development		x	x			2
Pollen reaches the stigma		x	x			2
Fertilization process		x	x			2
Pollination of yucca and fig			x			1
Seed and pollination			x			1
Structure of seeds and fruit			x	x		2
Fruits ripened ovaries			x			1
Varying structure and appearance of fruit			x			1
How seeds are made			x			1
Food may be stored outside cotyledons			x			1
Structure of corn grain			x			1
Changes in a sprouting grain			x			1
Stored seed foods insoluble in water			x			1
Other foods in seeds			x			1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
New plants from seeds				x		1
How fruits and seeds are scattered			x	x	x	3
Seeds must get away from point of origin				x		1
Long distances by water				x		1
Animals as seed scatterers				x		1
Extinction of species	x					1
Preservation of the species	x			x	x	3
Life spans, plants and animals					x	1
Longest and shortest lived organisms					x	1
Asexual reproduction in seed plants	x				x	2
Asexual reproduction in animals	x					1
Similarities in reproductive processes					x	1
Significance of sexual and asexual reproduction	x		x			2
Embryology and growth	x	x	x	x	x	5
Development of the chick		x		x		2
Frog	x			x		2
Mouse	x	x		x		3
Human		x		x		2
Period of gestation				x		1
Steps in growth		x	x			2
Sizes of cells		x				1
Conditions of growth		x				1
Preformation		x				1
Transformation		x				1
Origin of tissues		x				1
Differentiation	x	x	x			3
Similarities in development		x				1
Conditions for development		x				1
Recapitulation		x	x		x	3
Chemical influences		x				1
Inner factors		x				1
Metamorphosis	x				x	2
Metamorphosis in man		x				1
Twins and quintuplets		x				1
Cell position important in development		x				1
Dorsal lip of gastrula		x				1
Degenerates	x					1
Classification based on changes from infancy to parenthood	x					1
When does life begin	x					1
Food for embryos of obiparous animals	x					1
Purpose of incubation	x					1
Precocial and altricial birds	x					1
Other aspects of embryonic development	x					1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	Tl
Infancy and parenthood	x	x	x		x	4
Lines of differentiation		x				1
Vegetative and reproductive		x				1
Infancy among animals		x				1
Infancy in man		x				1
Parent behavior		x				1
Activities necessary for living, plus		x				1
The human point of view	x	x				2
Permanency in animal mating	x					1
The family and civilization		x				1
No field and woodland schools			x			1
Relationship, degree of development and care of young	x					1
Parental care in plants	x	x				2
Care of the egg			x			1
No infancy in one celled forms	x					1
Heredity and variation	x	x	x	x	x	5
Race experience		x				1
Gregor Mendel	x	x	x	x	x	5
Dominance		x	x	x	x	4
Segregation		x		x	x	3
Independent assortment		x	x		x	3
Rediscovery of Mendel	x	x	x			3
Practical applications of laws			x			1
Pure strains			x			1
Combination of characters			x			1
Rules and exceptions		x	x			2
What is inherited		x				1
Chromosomes	x	x	x	x	x	5
Interaction of factors		x	x		x	3
Chromosome maps		x				1
Chromosomes in inheritance			x		x	2
Defective chromosomes		x				1
Genes and germ plasm	x	x	x	x	x	5
Two sets of genes			x			1
Segregation					x	1
Cumlative genes			x			1
Possible combinations	x					1
Traits transmitted by unit characters	x					1
Are behavior traits unit characters?	x					1
Reduction division, gametogenesis	x	x	x		x	4
In plants					x	1
In animals					x	1
Fertilization and the law of chance					x	1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Chromosomes and linkage		x	x			2
Inheritance of sex			x		x	2
Crossing over			x		x	2
Sports and mutations	x	x	x	x	x	5
Changes in chromosome number				x	x	2
Recombinations					x	1
Some changes useful, some not				x		1
Variations		x		x	x	3
Physical, chemical, organic		x				1
Inheritance of differences		x				1
Variations from ordinary cell division			x			1
Causing variations			x		x	2
Second generation hybrids	x	x	x			3
Differences in second generation hybrids			x			1
The 1:2:1 ratio	x		x			2
Explaination of throwbacks			x			1
Blended inheritance	x			x	x	3
Lethal factors					x	1
Aquired variations					x	1
Normality		x				1
The one and the many		x				1
The average and the normal		x				1
Normal variation		x				1
Importance of individual difference		x				1
The individual and individuality		x				1
Equality and individuality		x				1
Individuality amongst all living things		x				1
Kinds of resemblances		x				1
Inheritance of two traits				x		1
Identical twins				x	x	2
Unmodified development, guinea-pig ovary					x	1
Madifying development in paramecia					x	1
In plants					x	1
Examples of heredity				x		1
Hair color in mice				x		1
Short haired rabbits				x		1
Recessive yellow tomatoes				x		1
Necessity for more than just biological inheritance	x	x				2
Experiment with jimson weeds				x		1
Heredity vs. environment	x			x		2
Genetics			x	x		2
The basis of heredity	x					1
Human inheritance	x	x	x	x	x	5
Human hybrids		x	x			2

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Evolution and man		x				1
Human races		x	x		x	3
Secondary, mixed races			x			1
Sub races					x	1
The study of human inheritance					x	1
Heredity in man		x				1
Human types and cultures		x				1
"Race superiority"		x				1
Our present knowledge of human heredity					x	1
Single factors in human inheritance					x	1
Sex linked inheritance in man					x	1
Multiple factors in human inheritance					x	1
Inheritance of mental traits					x	1
Desirable qualities					x	1
Deficiencies					x	1
Improvement of the human species					x	1
Eugenics			x		x	2
Research					x	1
Education					x	1
Legislation					x	1
Heredity and environment in identical twins			x			1
Aquired characteristics not inherited			x			1
Social and political aspects of heredity			x			1
Good and bad Killikaks	x					1
Who were the Killikaks?	x					1
The Jukes	x					1
The case of 32 poor whites	x					1
Mental ability and environment	x					1
Back to the Jukes and Killikaks	x					1
Inheritance of susceptibility to disease				x		1
The electroncephalograph				x		1
Should you marry a relative?				x		1
Difficulties in studying heredity				x		1
Breeding	x	x	x	x	x	5
Need for better types of organisms		x				1
Breeding for immunity		x				1
Breeding for uniformity and vigor		x	x	x		3
The legend of Llewelyn and Gelert				x		1
Man may produce new types				x		1
The sport or bud mutation				x		1
Plant breeding			x		x	2
Hardy fruits for Northwest			x			1
Crops for West and Southeast			x			1
Other plant breeding results			x			1
Pure line plants			x			1
Plant population			x			1
A tomato with wiskers				x		1
Problems of animal breeding	x	x	x		x	4

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Improvement in domestic animals	x		x			2
Pure bred animals			x			1
Poultry for high egg production	x					1
Controled breeding in animals				x		1
Hybridation	x		x		x	3
Hybrid vigor			x			1
Pure line hybrids			x			1
Hybrids in domestic animals			x			1
Securing uniformity in hybrids			x			1
Hybrids unsuited for breeding stock	x		x			2
Pedigree culture					x	1
Hybrids and selective breeding	x				x	2
Inbreeding hybrids	x				x	2
Variation and selection					x	1
Opportunities in plant and animal breeding			x			1
Breeding methods of the past					x	1
Modern breeding methods					x	1
Evolutionary development	x	x	x	x	x	5
Life in the past	x	x	x	x	x	5
How did life begin?		x	x			2
Choice of assumptions		x				1
Has life always existed?		x	x			2
Life from afar?		x				1
Scientist's dilemma		x				1
Vitalism		x				1
Life from non-living matter		x				1
Between living and non-living		x				1
Our limited knowledge		x				1
Special creation		x				1
Many creations		x				1
The measurement of geologic time	x		x	x	x	4
The earth calendar			x			1
Age of the earth			x	x		2
Azoic time to Cenozoic					x	1
Classification of rocks			x	x		2
Fossils	x	x	x	x	x	5
Kinds of fossils					x	1
Fossils in the rocks		x	x	x		3
Interpreting fossil facts		x	x			2
Refrigerated fossils		x				1
Fossil records of particular groups	x					1
Formation of fossils					x	1
Resemblances and relationships		x		x	x	3
Measures of resemblance		x				1
Resemblance in development		x				1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Changes in species					x	1
Evidences in embryos					x	1
Changes in living things in the present					x	1
New varieties					x	1
New species					x	1
Changes in species population					x	1
Human migration effects species population					x	1
Resemblance of structure and function					x	1
Vertebrates and invertebrates					x	1
Similarities in the dog genus					x	1
Similarities among plants					x	1
Similarities between plants and animals					x	1
Homology and analogy		x				1
Vestigial structures		x			x	2
Geographic distribution		x	x		x	3
Facts and explainations		x				1
LaMark's explaination and objections to it	x	x			x	3
Theory of radiative adaptation			x			1
Charles Darwin		x		x		2
Natural selection and objections		x	x	x	x	4
Origin and varieties of domestic plants and animals			x			1
Parallel development			x			1
Development of plants			x			1
Early land plants			x			1
New forms in Mesozoic era			x			1
Rise of the angiosperms			x			1
Animals of the ancient seas			x			1
Early fishes			x			1
Teleosts, modern fish			x			1
Early land animals			x			1
Scorpions			x			1
Early insects			x			1
First land vertebrates			x			1
Passage to the land			x			1
History of reptiles			x			1
Origin of birds			x			1
Development of mammals			x			1
History of the placental mammals			x			1
How the elephant got its trunk	x					1
New species or new individuals		x				1
Change as catastrophic	x					1
Change as gradual	x		x			2
Do living things change?	x		x			2
Development of modern domestic animals	x					1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Indications of gradual continuous change	x					1
Questions of origin of life and of species		x				1
Mankind changes				x		1
Java man to Homo-Sapiens				x		1
The future of man				x		1
Causes of change	x			x		2
Evolution needs further explaination	x					1
Body systems and functions	x	x	x	x	x	5
Circulation	x	x	x	x	x	5
How does food reach the cells?	x					1
The circulatory system	x	x	x	x	x	5
The heart and blood vessels	x	x	x	x	x	5
Circulation through heart	x			x		2
Through arteries	x					1
Pulmonary and systemic circulation		x		x		2
The portal vein	x					1
Circuits in human circulatory system	x					1
Cappilaries in small intestine	x					1
Circulation in lower animals	x				x	2
Amoeba	x					1
Hydra	x					1
Earthworm	x				x	2
Insect	x				x	2
Vertebrate	x				x	2
Changes in circulation		x				1
Blood	x	x	x	x	x	5
White corpuscles		x	x	x		3
Red corpuscles		x	x	x		3
Clotting		x				1
Blood chemistry		x				1
Stability of the blood		x				1
Lymphatic system	x	x	x	x	x	5
Food stored in the liver	x					1
Fats get into the blood stream	x					1
Surplus storage and deficiencies		x				1
Overflow, kidneys and lungs		x				1
Hunger and intake		x				1
Increase and decrease in pulse rate		x				1
Heart disease				x		1
Transfusion		x		x		2
Blood banks		x		x		2
Flying, affect on circulation		x		x		2
Body conditions demanding specialized circulatory system	x					1
Specialized adaptations	x					1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Specialized adaptations	x					1
Historical notes	x					1
Primative man and circulation	x					1
Hippocrates and Aristotle	x					1
Galen	x					1
Harvey	x					1
Discoveries since Harvey	x					1
Respiration	x	x	x	x	x	5
What is respiration?	x	x	x			3
Relation of air to life		x				1
Gas exchange of the cell	x	x		x		3
Air and energy	x	x				2
Air as a raw material		x				1
Respiration in plants	x	x	x			3
Breathing in man		x	x	x		3
Lungs, higher vertebrates	x	x				2
Acidosis and alkalosis	x					1
Function of insulin	x					1
Blook red, haemoglobin	x	x				2
Carbon dioxide removed from cell	x					1
Carbon dioxide influences breathing	x					1
Comparison of organism to gas engine	x					1
Ventilation	x					1
Humidity and temperature	x					1
Exchange of gases in the lungs				x		1
Diseases of the respiratory tract				x		1
Structure of nasal passages				x		1
Infections of respiratory tract				x		1
Respiration a universal life process			x			1
Products of respiration			x			1
Skeleton and muscles	x		x	x		3
Mammalian skeleton			x	x		2
Limbs			x			1
Head and neck forms			x			1
Skeleton aids in producing movement	x			x		2
Joints	x					1
Muscles	x		x	x		3
Contractility	x			x		2
Cell structure of muscles				x		1
Renewal of energy in muscles				x		1
Care of bones and muscles				x		1
How is movement produced?	x					1
Characteristics enabling muscles to do work	x					1
Movement without a skeleton	x					1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
The integument	x	x		x		3
Body covering	x			x		2
Modifications of epidermis	x			x		2
Structure of mucus membrane	x					1
Human skin	x					1
Importance of skin and its origin				x		1
Regulation of body temperature			x			1
Food getting and excretion	x	x	x	x	x	5
Food getting adaptations	x	x	x		x	4
Mouth parts of a squirrel	x					1
Adaptations of other parts of squirrel	x					1
Squirrel's habits	x					1
Rule of life, to eat and escape being eaten	x					1
Kinds of feeders	x	x				2
Herbivorous animals	x	x				2
Carniverous animals		x				1
Food getting and food using		x				1
Intermittent feeding (hibernation etc.)		x				1
Termites secure food			x			1
Man's mouth parts, omnivorous	x					1
Digestion and the digestive tract	x	x	x	x	x	5
Digestive tract	x	x	x	x	x	5
Mouth, teeth, throat				x		1
Saliva	x			x		2
The oesophagus and stomach	x	x		x		3
Digestion in the stomach	x	x				2
Removal of food from the stomach	x					1
Intestines	x	x		x		3
Intestinal digestion	x	x				2
Large intestine	x	x		x		3
Absorption of digested food		x		x		2
Enzymes	x	x	x			3
Swallowing	x					1
Work of tongue and soft palate	x					1
Glands and juices		x		x		2
Purpose of digestion	x		x			2
Physical and chemical digestion	x				x	2
Disturbances of digestion				x		1
Acidity and alkalinity in digestion	x					1
Elimination and its relation to health	x					1
Laxatives and their uses	x					1
Early views on digestion	x					1
Discovery of nature of stomach digestion	x					1
Assimilation					x	1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	Tl
The skin	x					1
Rate of work		x				1
Fatigue and efficiency		x				1
Fatigue may be general		x				1
Getting tired		x				1
Nwphridia	x					1
Plant disposal of wastes	x	x				2
Behavior, sensitivity and response	x	x	x	x	x	5
Sensitivity and response	x	x	x	x	x	5
What is behavior?	x					1
Plant responses	x	x	x		x	4
Seasonal adjustment		x				1
Illumination and leaf growth		x				1
Light and growth		x				1
Changing illumination		x				1
Water changes		x			x	2
Growth substances		x	x			2
Growing buds produce substance preventing growth of other buds			x			1
Sleep movements					x	1
Rapid responses					x	1
Response by variation in growth					x	1
Tropisms, simple responses		x	x	x	x	4
Plant hormones		x			x	2
Geotropism		x				1
Light and phototropism				x	x	2
Hydrotropism and other turnings					x	1
Animal tropisms		x	x	x	x	4
In amoeba					x	1
In paramecia					x	1
Other protozoa					x	1
Can a protozoan learn anything					x	1
Behavior of one celled animals					x	1
Tropisms, reflexes and instincts		x	x			2
The senses	x	x	x	x	x	5
Sensitivity to light	x	x			x	3
Hearing, taste, smell, feeling	x				x	2
Balance				x	x	2
Senses and adjustment		x				1
More than 25 senses					x	1
Irritability in plants, sensitive plant			x			1
Fitness and response		x				1
Chemical sensitiveness		x				1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Function of water in the body				x		1
Chemical regulators, mineral		x	x	x		3
What is food?				x		1
Measuring the energy content of food			x	x		2
Food groups		x		x		2
Carbohydrates			x	x		2
Fats				x		1
Bulk or roughage				x		1
Uses of carbohydrates and fats			x			1
Food habits	x				x	2
Early ideas on foods	x					1
Principles and rules of human diet		x	x			2
More than day by day		x				1
Schemes and rules		x				1
Share technique		x				1
The well balanced diet					x	1
Keeping body at proper weight			x			1
Reducing	x		x		x	3
Dangers	x		x			2
Principles of reducing diet			x			1
Example			x			1
Diet for underweight persons			x			1
Sensitivity to foods			x			1
Danger of dietary deficiencies			x			1
Food reserves			x			1
Testing for nutrients in certain foods					x	1
Sweets				x	x	2
Enriched flour		x			x	2
Food drug and cosmetic racketeers				x		1
Public enemy no. 1				x		1
Pure food and drug act				x		1
Adulterated foods				x		1
Buyer beware				x		1
Wisely varied diet					x	1
Food fads and nutrition					x	1
Waste removal	x	x	x	x	x	5
The origin of wastes in living things	x	x				2
Removal of wastes from cells		x				1
Why wastes must be removed	x					1
Human uses of organic waste products		x				1
Excretion in animals	x	x	x	x		4
The kidney	x	x	x	x		4
Glomerulae		x				1
Composition of the urine		x				1
The lungs	x	x				2

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Digestion is universal	x	x	x		x	4
Digestion in bacteria	x					1
In higher plants	x					1
In lower animals	x		x		x	3
Digestion in frog	x				x	2
Digestive system of a bird	x					1
Herbivorous digestive system	x					1
Conclusions concerning digestion	x					1
Importance of good digestion				x		1
Metabolism and nutrition	x	x	x	x	x	5
Food needs of the body	x	x				2
Energy to keep going	x	x		x		3
How much food should we eat	x					1
Building needs		x				1
Energy used in activities		x				1
Energy needs of different workers		x				1
Above the base line		x				1
Daily energy needs	x	x		x		3
Calories	x	x		x	x	4
Respiration calorimeter	x					1
Computing requirements	x				x	2
Basal metabolism	x	x		x		3
Rate	x					1
Standards		x				1
Measuring body work		x				1
How does food act in living protoplasm		x				1
Proteins, protoplasm builders	x	x	x	x		4
Kinds needed	x					1
How steady the protein demand of body?	x					1
Uses of proteins			x	x		2
Many proteins expensive foods				x		1
Chemical needs of the body	x	x		x		3
Inorganic substances needed, minerals	x	x		x	x	4
Special elements		x				1
Vitamines	x	x	x	x	x	5
How the sailor became a limey		x				1
Development of knowledge of vitamines	x	x				2
Importance of vitamines			x	x		2
Vitamine action	x	x		x		3
Names and facts	x	x	x	x		4
Differentiation		x		x		2
Sources		x				1
Concentrates	x					1
Vitamines and diet	x				x	2
Proper cooking to maintain vitamines				x		1
Water an important part of food				x		1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
The nervous system	x	x	x	x	x	5
Types of animal response systems					x	1
Protozoan					x	1
Cell colony					x	1
Simple metazoa					x	1
Annelid					x	1
Arthropod	x				x	2
Vertebrate	x				x	2
Special cells for special functions	x	x	x	x		4
Nerve cells		x	x		x	3
Electrical changes in nerve tissue			x			1
Synapse					x	1
The brain	x	x	x	x	x	5
Development of brain and spinal cord			x		x	2
Living without a brain	x	x				2
Brain and reflexes		x				1
Cerebrospinal fluid			x			1
Injury and defects of the brain			x			1
Lower brain functions	x		x			2
The cerebrum	x		x			2
Functions of the cerebrum	x		x			2
Functions of the cerebellum	x		x			2
Nerve fibers or bundles	x		x			2
Main nerve axis, spinal cord		x	x			2
Function of spinal cord			x			1
Our double nervous system		x			x	2
The autonomic nervous system	x		x			2
Central nervous system			x			1
Peripheral nervous system	x				x	2
Elements of the nervous system			x	x		2
Afferent and efferent nerves			x			1
The nerve impulse		x	x	x		3
Voluntary and involuntary	x	x	x			3
Control of the heart action	x					1
General and special sensitiveness		x				1
Compound eyes		x				1
The vertebrate eye		x		x		2
Structure of the human eye	x					1
How the human eye works	x					1
The retina	x					1
Color blindness	x					1
Blind spot	x					1
Defective vision	x			x		2
Sight in lower animals	x					1
Hearing and the ear	x	x		x		3
Defects				x		1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Structure of the human ear	x					1
Range of vibrations	x					1
Ears of other animals	x					1
Other sense organs	x					1
Position of mammalian eyes and ears			x			1
Nervous system connects and coordinates body parts			x			1
Speed and efficiency of animal responses					x	1
Significance of speed					x	1
Efficiency of response					x	1
Coordinated response					x	1
Hormones and glands	x	x	x	x	x	5
The endocrine system	x	x	x	x	x	5
Pituitary	x	x	x		x	4
Pituitary hormones			x			1
Thyroid	x		x		x	3
Hyperthyroid			x			1
Hypothyroid			x			1
Goiter			x			1
Thymus			x			1
Adrenal glands	x		x		x	3
Effects of adrenalin			x			1
Function of cortin			x			1
Pineal gland			x			1
Pancreatic islands	x		x		x	3
Liver			x			1
Parathyroids			x		x	2
Glands of the reproductive organs		x	x			2
Other endocrine glands	x		x		x	3
Hippocrates and the humors	x	x				2
Chemical foundations	x					1
Chemical factories	x	x				2
Modern humors		x				1
Hormones, endocrines	x	x	x			3
Importance			x			1
Controls		x				1
Emergencies		x				1
Adolescent changes	x					1
Other hormone like substances	x					1
Hormones vitamines and enzymes	x					1
Endocrinology			x			1
Psychology	x	x	x	x	x	5
What must be known to predict behavior	x					1
Reflex arc	x		x	x	x	4

BOSTON UNIVERSITY
COLLEGE OF LIBERAL ARTS
LIBRARY

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Instincts and habits as chains of arcs	x			x		2
Natural reflex action		x	x	x		3
Conditioned reflexes		x	x		x	3
Human automata		x				1
Instincts and habits in relation to goals	x					1
Stimulus response theory	x					1
Goal-insight theory	x					1
Consequences of goal-insight interpretation	x					1
Goal-insight theory and our outlook on life	x					1
Relation of higher nerve centers to habits	x					1
Habits and behavior	x	x	x		x	4
Forming habits			x			1
Changing habits			x			1
Importance of habits					x	1
Permanency of conditioned behavior			x			1
Habits as fixed sequences of acts	x					1
Emotions and their effect on behavior		x	x			2
Hypothalamus			x			1
Emotional responses			x			1
Feeling and action			x			1
Theory of emotion			x			1
Emotional action unintelligent			x			1
Natural and conditioned emotions			x			1
Joy and sorrow		x				1
Organic aspect of the emotions		x				1
Attitudes		x				1
Intelligence and human behavior		x	x			2
Intelligence influences conduct			x			1
Man's respect for intelligence			x			1
Duty of intelligence			x			1
Instincts		x	x			2
Definition of instinct			x			1
Changing instincts		x	x			2
Hen and chickens			x			1
Solifuge and scorpion			x			1
Other examples			x			1
Characteristics of instinctive responses			x			1
Relation of stimulus to accompanying stimuli	x					1
Overlordship of the brain			x			1
Learning and feeling	x	x				2
Training and education		x				1
Adjustments		x				1
Hormones as unifiers		x				1
Kinds of learning		x				1
Physical basis of mental disturbances		x				1
Effects of ideas on organic processes		x				1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	Tl
Mental health and mental healing		x				1
The mind unifies the organism		x				1
What is mind?		x				1
What is happiness?		x				1
Pain and pleasure		x				1
Pain and privation		x				1
Positive needs		x				1
Values		x				1
Obstacles to satisfaction		x				1
Increasing the range of needs		x				1
Substitute balues		x				1
Aesthetic values		x				1
Anticipation		x				1
Learning restraints		x				1
Becoming human		x				1
Discovering ourselves		x				1
Social sensitivity		x				1
Human possibilities		x				1
Neuroses		x				1
Mental disorders					x	1
Memory, thought and reason					x	1
Mental health	x			x		2
High school students mental stability	x					1
Mental troubles universal	x					1
Rules for mental health				x		1
Health and sickness	x	x	x	x	x	5
Health on a national scale	x	x	x			3
The health of our people	x					1
Why some more healthy than others		x				1
Poverty and sickness		x				1
Sickness and ignorance		x				1
Ways of living and sickness		x				1
Increased life expectancy	x					1
Increasing and decreasing death rates	x					1
Chief killers	x					1
The government and microbes	x	x				2
Preventive medicine, public health service	x	x				2
U.S. Public Health Service	x					1
Prohibitions and regulations		x				1
How we measure sickness		x				1
The increased life expectancy	x					1
Water and sewage disposal		x				1
Food protection		x				1
Food in wartime		x				1
Working conditions		x				1
Health problems affect us all			x			1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	Tl
The fight against disease	x	x	x	x	x	5
Animal microbes		x	x			2
Transmission of protozoan disease			x			1
Menace of protozoan infection			x			1
Parasitic worms		x	x			2
Tapeworm			x			1
Flukes			x			1
Hookworm		x				1
Seriousness of worm infections			x			1
Ticks and mites		x	x			2
Parasitic insects			x			1
Specific diseases	x			x		2
Insect borne disease		x				1
Mouth diseases and bacterial infection	x					1
Importance of parasites and their control	x					1
Communicable diseases and germs	x	x		x	x	4
In early times	x					1
Early theory of causes	x					1
Germ theory of disease	x	x			x	3
Leeuweenhoek	x		x	x		3
Semmelweis and childbed fever	x					1
Pasteur	x		x	x		3
Silkworm disease	x					1
Hydrophobia				x		1
Joseph Meister				x		1
Other work	x			x		2
Lister and sntiseptic surgery	x					1
Koch and anthrax	x					1
Jenner and smallpox	x					1
Present day knowledge of germ diseases	x					1
Kinds of disease germs	x					1
Causes of distribution of diseases	x					1
Specific tests of disease		x				1
Filterable viruses		x	x			2
Virus infection		x	x			1
Control of virus infections			x			1
Virus mutations			x			1
Non-specific diseases		x				1
The fight against specific diseases		x				1
Not all germs harmful to man	x					1
Protection from contageous diseases				x		1
Various groups working for control				x		1
Many contageous diseases on may out				x		1
Diseases spread by impure water and milk				x		1
Laws for butchers and meat packers				x		1
Protection for city dwellers				x		1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
The fight against cancer	x			x		2
What is it and how can it be detected in early stages?	x			x		2
Symptoms	x					1
Guarding against cancer	x			x		2
Caught or hereditary?	x			x		2
Treatment	x			x		2
Diseases of heart and circulation	x					1
Increasing death rate	x					1
Dr. Page and blood pressure	x					1
Allergies	x	x		x		3
Eat and suffer				x		1
Allergy tests				x		1
Hay fever				x		1
Anaphylaxis		x				1
Dr. Tredeau and T.B.	x					1
Natural defense against germs	x					1
General resistance	x					1
Effect of changes in body temperature	x					1
Bacteriophage	x					1
Chemotherapy and magic bullets	x					1
Chain of infection		x				1
Fighting the house fly		x				1
Wounds and germs		x				1
Immunity and susceptibility	x	x	x	x	x	5
Reaction of animal body to bacterial infection			x	x		2
Defense mechanism	x					1
Chemical conflict		x				1
Vaccination		x	x			2
Sera and reactions	x	x	x			3
Toxin, antitoxin, toxoid	x					1
Preparation of sera	x					1
Permanent value of immunization		x				1
Contrast of active and passive immunity			x			1
Immunities	x		x	x		3
Carriers		x				1
Healthand sickness		x				1
Evil spirits		x				1
Sickness and sin		x				1
Physical health affected by the mind		x				1
Truth in falsehood		x				1
Pathogenic bacteria			x			1
How they cause disease			x			1
Specialization and adaptability			x			1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
First aid	x			x		2
What first aid is				x		1
Control of severe bleeding				x		1
Artificial respiration				x		1
"Mouth" poisonings	x			x		2
Slow poisond, metalic	x					1
Painter's colic	x					1
Fainting				x		1
Heart failure to corns				x		1
Three kinds of fractures	x			x		2
Mechanical injuries	x					1
How a bone breaks	x					1
Snake bites	x			x		2
Sprains and dislocations	x					1
Wounds	x					1
Relation of pain to injury	x					1
Foods and drugs compared	x					1
Sedatives	x					1
Stimulants	x					1
Health a personal matter	x	x	x	x	x	5
Are we solving health problems?	x					1
Quacks	x					1
Irregularities in development		x				1
Ways of living		x				1
Personal hygene and immunity to disease			x	x		2
Inform yourself as to effects of some substances on metabolism and health	x		x	x		3
Commonly used habit forming substances			x	x		2
Changed cell metabolism			x			1
Alcohol and its affect			x	x		2
Tobacco	x			x		2
Marijuana				x		1
What to do for a cold	x					1
Common colds sometimes fatal				x		1
Can we afford slums?	x					1
Infant health in E. Harlem	x					1
Facts on a slum area	x					1
Contact diseases				x		1
Cleanliness				x		1
Importance of sleep				x		1
Exercise				x		1
Sunshine				x		1
Care of hair				x		1
Healthful clothing				x		1
Posture				x		1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Protection from accidents	x				x	2
Safety laws					x	1
Individual responsibility					x	1
Classification	x	x	x	x	x	5
General, plant and animal	x	x	x	x	x	5
General scheme of classification	x	x	x	x	x	5
Basis for classification	x	x			x	3
Naming before sorting		x			x	2
Assembling and separating		x			x	2
Need for many names	x	x		x		3
Why plants are classified				x		1
Why animals are classified				x		1
Discrimination		x				1
Double names	x	x	x	x	x	5
Species		x	x		x	3
Kinds of divisions		x		x	x	3
Relationship of species		x				1
Universal naming system	x		x	x		3
Classifying, using keys			x		x	2
Ways to tell plant from animal				x		1
Linnaeus	x		x	x		3
How we can know different kinds of living things		x				1
Plants			x	x	x	3
The plant animals			x		x	2
Fungi			x			1
Slime molds			x			1
The molds					x	1
How they increase					x	1
Spoilage					x	1
Not all cause spoilage					x	1
Ringworm					x	1
Penicillin					x	1
Mildews					x	1
Other parasitic fungi					x	1
Mushrooms and toadstools			x	x		2
Puffballs			x			1
Bracket fungi			x			1
Importance of fungi			x			1
Smuts and rusts				x		1
Yeasts				x		1
And health				x		1
Produce alcohol				x		1
Filterable viruses			x	x		2

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Nature of filterable viruses			x			1
A third kingdom?			x			1
Lichens				x		1
Algae				x		1
Diatoms				x		1
Seaweeds and pond scums				x		1
Colonial algae				x		1
Bryophytes			x	x		2
Mosses			x	x		2
Reproduction			x	x		2
Peat moss			x			1
Ancestral structures			x			1
Liverworts			x	x		2
Pteridophytes, ferns			x	x		2
Ancient plants				x		1
Reproduction				x		1
Fern relations			x			1
Structures			x			1
Comparison of moss and fern			x			1
How a plant is named				x	x	2
Classifying apples					x	1
Classification of the delicious apple				x		1
Spermatophytes			x	x		2
Gymnosperms			x	x		2
Gymnosperm reproduction			x			1
Angiosperms			x	x		2
Dicots			x	x		2
Oak to potato			x	x		2
Types of dicot leaves			x			1
Monocots			x	x		2
Seed production in angiosperms			x			1
Advances from gymnosperm to angiosperm			x			1
Ecological relationships of land plants			x			1
Water relationships			x			1
Light			x			1
Temperature			x			1
Brilliant flowers in arctic plants			x			1
Importance and success of land plants			x			1
Animals	x		x	x	x	4
Protozoa			x	x	x	3
Importance of protozoa				x		1
Miniature zoological gardens					x	1
Sponges			x	x		2
Varieties			x			1
Structure			x			1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Colenterates			x	x	x	3
Body plan			x			1
Life processes			x		x	2
Planaria, flatworms			x	x	x	3
Body plan			x		x	2
Life processes			x		x	2
Tapeworms				x		1
Flukes				x		1
Roundworms			x	x		2
Ascaris			x			1
Trichina			x	x		2
Hookworms				x		1
Echinoderms				x		1
Mollusks				x		1
Earthworms			x	x	x	3
Body plan			x	x	x	3
Abundance and importance			x	x		2
Arthropods			x	x		2
Moulting and metamorphosis			x			1
Crustacea				x		1
Others			x	x		2
Arachnids			x	x		2
Spiders			x			1
Scorpions			x			1
Insects	x		x	x		3
Importance of insects				x		1
Combating insects				x		1
Collecting rearing and preserving				x		1
What an insect is				x		1
Characteristic structure			x	x		2
Special structures				x		1
Life history of insects				x		1
Success of insects			x			1
Injurious insects			x	x		2
Beneficial insects				x		1
Representative insects			x	x		2
Grasshopper			x			1
House fly			x			1
Mosquito			x			1
Wasps			x			1
Interpreting facts about insects			x	x		2
Interesting insect facts				x		1
Communal life of insects	x					1
Solitary vs Communal living	x					1
Solitary wasp	x					1
Communal life of the bee	x					1

TABLE I (CONTINUED)

TOPICS	A	B	C	D	E	T1
Manufacture of honey and honeycomb	x			x		2
Adaptations in communal life	x					1
Communal life of ants	x					1
Termites	x			x		2
Damage caused by termites	x					1
Communal life of man - a comparison	x					1
Relationship of animal phyla			x			1
General characteristics of the			x	x		2
vertebrate body			x			1
Body plan			x			1
Development			x			1
Fishes			x	x		2
Special features			x			1
Internal organs			x			1
Migration			x			1
Lungfishes			x			1
Adaptability of fish			x			1
Value of fish				x		1
Amphibians			x	x		2
Salamanders			x	x		2
Frogs and toads			x	x		2
Value of amphibia				x		1
Reptiles			x	x		2
Harmful and useful				x		1
Lizzards			x			1
Snakes			x	x		2
Body			x			1
Non-poisonous in U.S.			x			1
Poisonous in U.S.			x			1
Other poisonous snakes			x			1
Crocodiles and their relatives			x			1
Turtles and tortoises			x	x		2
Sphenodon			x			1
Transition to life on land			x	x		2
Reptiles lay eggs on land				x		1
Birds			x	x		2
Characteristics			x	x		2
Intelligence and instincts			x			1
Eggs and their care			x			1
Biological relationships			x			1
Value of birds				x		1
Special features and adaptations			x			1
Moulting			x			1
Body of the bird			x			1
Life processes			x			1
Diversity and adaptations among birds			x			1

TABLE I (CONCLUDED)

TOPICS	BOOKS					
	A	B	C	D	E	T
Monotremes			x			1
Duckbill and spiney anteater			x			1
Marsupials			x			1
Kangaroos and Wallabies			x			1
Other Australian marsupials			x			1
American marsupials			x			1
Placental mammals			x	x		2
Claw footed			x			1
Hoofed mammals			x			1
Whales			x			1
Primates			x			1
Lemurs			x			1
Monkeys			x			1
Apes			x			1
Man				x		1
Relationship of living placental mammals			x			1
Useful mammals				x		1
Value of mammals to man				x		1
Success of birds and mammals			x			1
Total 2078*	563	562	652	587	372	2736**

* This is the number of separate subject-matter topics.
** This represents the number of times all topics appeared in all books.

Findings. A total of 2,078 separate subject-matter topics were found a total of 2736 times in the five textbooks for an average of 547.5 topics per book. Of these, 2,078, only 73 were major topics. The remaining 2,005 were minor topics subordinate to the 73 major topics. Thirty-eight, or 52 percent, of the 73 major topics were found in each of the five books analyzed; 10 were found in 4 of 5 textbooks; 8 in 3; 4 in 2; and the remaining 13 in only one textbook. Of the 13 major topics to be found in only

one textbook, 3 came from a specific section of one book and 6 came from a specific section of a second book. If these 9 relatively insignificant topics be disregarded, 48, or 75 percent, of the 64 remaining major topics were found in 4 or more of the 5 textbooks. Only 159, or 7.5 percent, of the 2,005 minor topics were found in 3 or more of the five books.

CHAPTER III

SUBJECT-MATTER TOPICS ALLOCATED TO BIOLOGICAL PRINCIPLES

Statement of the Problem

The purpose of this part of the investigation was to assign to biological principles those topics which a study of should contribute to the development of an understanding of the principles.

Techniques Employed

The topics used in this part of the investigation were obtained from the composite outline reported in Table I. Only the 73 major topics (topics of the first and second order in the outline) to which all other topics were subordinate topics were selected to be assigned to the biological principles.

Martin's[1] list of 300 biological principles was deemed to constitute a satisfactory list of principles to which topics could be assigned. Whenever it was the investigator's opinion that the discussion of a topic might be reasonably expected to include material that would contribute to the understanding of a principle, or if it was felt that the

[1]William Edgar Martin, A Determination of the Principles of the Biological Sciences of Importance for General Education, Unpublished Doctor's dissertation, University of Michigan, 1944.

topic might be used to develop an understanding of the principle, the topic was assigned to that principle. This was done with no attempt made to place the topics in any order of preference.

In order to insure the defensibility of the assignments of topics to principles, a copy of the list of biological principles with the topics which had been assigned to them by the investigator was submitted to each member of a jury of three subject-matter specialists*. Each specialist was asked to check the list critically to insure that no topic was assigned to a principle to which it might not be reasonably expected to contribute an understanding, or which it might not be used to develop. Each was asked to check any assignment of a topic which he considered not defensible, and to initial each page examined. Where a principle was assigned a topic which was questioned by any one of the specialists, the investigator discussed that assignment with the three specialists and an adjustment was made to satisfy all three.

*Eugene V. Lovely, Principal of Punchard High School, formerly teacher of high-school biology; Mrs. Maxine S. Miles, formerly on the staff of the zoology department and of the Medical school, University of Michigan; Dr. (Mrs.) Abigail K. Blake, specialist in botany, with a degree from the University of Nebraska.

Table II presents Martin's list of 300 biological principles, each of which is followed by those topics deemed to contribute to an understanding of it. The arrangement of Martin's list of principles in descending order of their relative importance for general education is retained in Table II.

The topics which could not be defensibly assigned by the investigator to a biological principle are in the appendix, page .

TABLE II

BIOLOGICAL PRINCIPLES, AND TOPICS WHICH MAY BE USED TO DEVELOP AN UNDERSTANDING OF THEM

1. The food requirements of every living thing are: fuels capable of yielding, when oxidized, the supply of energy without which life cannot continue; materials for growth and for replacement for the slight wearing away of the living tissue involved in any activity; minerals, the necessary constituents of cell structures, of cell products, and of the bathing fluid of cells.

Metabolism and nutrition*

2. The cell is the unit of structure and function in all organisms.

The cell and cell theory

3. The protoplasm of a cell carries on continuously all the general processes of any living body; the processes concerned in the growth and repair of upbuilding of protoplasm (anabolism) and the processes concerned with the breaking down of protoplasm and elimination of wastes from the cell (catabolism). The sum of all these chemical and physical processes is metabolism.

Protoplasm
Metabolism and nutrition
Waste removal

4. Reproduction is a fundamental biological process that provides for the continuance of life on the earth by providing new individuals.

Reproduction

5. Circulation is carried on in all living organisms. With increase in size and complexity of the body of an organism there goes a corresponding elaboration of the transportation (circulatory) system.

Circulation

6. All living organisms (except viruses and bacteriophage) carry on the common life processes; reproduction, growth, nutrition, excretion, respiration, and irritability.

*Table II is read thus: The topic "metabolism and nutrition" may be used to develop an understanding of the biological principle to which it is assigned.

TABLE II (CONTINUED)

Plant nutrition
Growth in plants
Reproduction
Respiration
Food getting and excretion
Sensitivity and response

7. In the presence of sunlight the chloroplasts of Chlorophyll-bearing plants convert the carbon dioxide and water into intermediate substances, and these into sugar and that into starch, and liberate oxygen, thus directly or indirectly producing practically all the food in the world.

Photosynthesis
Plant nutrition

8. A balance of nature is maintained through interrelations of plants and animals with each other and with their physical environment.

Interdependence of life
Conflicts of life

9. Cellular respiration (aerobic decomposition) occurs in all living cells and all organisms possess structures by means of which it can be carried on. Its first step is intake of oxygen either directly from the air or dissolved in water, its final product is carbon dioxide, and free energy is released. In the cells it is accomplished at ordinary temperatures by the intervention of special enzymes.

Respiration

10. Cells are organized into tissues, tissues into organs and organs into systems, the better to carry on the function of complex organisms.

The cell and cell theory
The unity of a living organism

11. In organisms the end products of metabolism; water, carbon dioxide, and nitrogenous compounds, are either stored in the cells as insoluble crystals, are eliminated in solution by diffusion or osmosis (excretion); are

TABLE II (CONTINUED)

incorporated into useful cell products (secretion); or are recombined into food substances within the organism.

Waste removal

12. Most cases of fermentation, souring and putrefaction are brought about by living micro-organisms.

Non-green plants get food
Bacteriology

13. Food, oxygen, certain optimal conditions of temperature, moisture and light are essential to the life of most living things.

What is life?
Limitations of life

14. All the higher forms of terrestrial life are dependant either directly or indirectly on the soil bacteria for their nitrogen supply.

Formation and composition of the soil
Bacteriology

15. In sexual reproduction a male cell from one parent unites with a female cell from the other parent to produce the young (except in the few cases of self-fertilization).

Reproduction

16. All communicable diseases are caused by micro-organisms.

The fight against disease

17. Protoplasm is the physical basis of all life.

Protoplasm

18. The multitude of interrelated neurons of the nervous system of higher animals form a complex system through which every organ of the body is in connection with every other organ.

The nervous system

TABLE II (CONTINUED)

19. Living things alter their types; present species have not always existed, but have originated by descent from others which in turn were derived from still earlier forms, and so down to the first living forms.

Evolutionary development

20. All living things respond to stimuli in their environment.

Sensitivity and response

21. The biological functions of color are to conceal, to disguise, or to advertise.

Adaptations for protection

22. A parasitic organism harms its host in various ways and to various degrees; by actively attacking the tissues, by shedding poisons, (toxins) which are distributed throughout the body of the host, by competing with the host for food or even by making reproduction of the host impossible.

Non-green plants get food
Bacteriology

23. All living things are slowly changing, both structurally and functionally, in response to changes in their physical environments.

Embryology and growth

24. Every species of organism is subject to certain checks or controls in the form of enemies and only those members that are most capable of avoiding their enemies survive to reproduce new offspring, and thereby transmit many of their characters to their offspring.

Conflicts of life
Evolutionary development

25. Protective adaptations aid survival.

Adaptations for protection

TABLE II (CONTINUED)

26. Digestion in plants and animals is carried on by enzymes, or organic catalysts, which are made by the organisms themselves and which take part in and speed up the chemical reactions but do not undergo any permanent chemical change themselves.

Digestion and the digestive tract

27. Enzymes, vitamines, and hormones are chemical regulators (stimulators and suppressors) of the reactions that occur in living organisms.

Digestion and the digestive tract
Metabolism and nutrition
Hormones and glands

28. Living things come only from living things.

Reproduction

29. All plants and animals are engaged in a constant struggle for energy.

Conflicts of life

30. The energy which makes possible the activity of most living things comes at first from the sun and is secured by the organism through the oxidation of food within the body.

Photosynthesis
Metabolism and nutrition

31. Regeneration is almost universal among living things; from the simple to the more complex animals the ability to regenerate lost parts and to reproduce asexually fall off, gradually and independently, as the body becomes more specialized.

Reproduction

32. All living cells require oxygen to provide energy or to build new protoplasm.

Respiration

TABLE II (CONTINUED)

33. Every cell consists essentially of a mass of protoplasm which is usually differentiated into a central portion, the nucleus, and an outer portion, the cytoplasm.

The cell and the cell theory
Protoplasm

34. Energy and matter are not created or destroyed in the reactions associated with the life processes, but are passed on from organism to organism in endless succession.

Some biological chemistry and physics

35. Throughout the life of every organism there is a building up and tearing down of protoplasm with constant transformations of energy.

Protoplasm

36. Infection by micro-organisms is possible only under the following conditions: 1. The infecting organism must enter the host in sufficient numbers; 2. It must enter by an appropriate avenue; 3. It must be virulent; 4. The host must be receptive.

The fight against disease
Bacteriology

37. Oxidation (combustion) furnishes the essential source of heat in the animal body; and other factors remaining constant, the more heat so produced the warmer the animal body.

Metabolism and nutrition
Respiration

38. Saprophytic organisms are responsible for decay by which process the necessary raw materials for growth of new organisms are released from dead matter.

Non-green plants get food

39. Living things are not distributed uniformly or at random over the surface of the earth, but are found in definite zones and local regions where conditions are favorable to their survival.

TABLE II (CONTINUED)

Limitations of life

40. The antitoxins produced by the body of an organism are specific.

The fight against disease

41. The surface of the earth and the atmosphere surrounding the earth are undergoing constant changes; therefore in order to survive organisms must migrate, hibernate, aestivate, build artificial shelters or otherwise become adapted to these changes.

Adaptations and interrelations of life

42. Certain associations of plants and animals are the result of a struggle for survival, for example, community or social life, parasitism and symbiosis.

Interdependence of life
Man and his relationships

43. All living organisms have other living things which compete with them for the available energy.

Conflicts of life

44. Water is essential to all living things because protoplasmic activity is dependent upon an adequate water supply.

Protoplasm

45. The germ plasm of animals and plants passes on from generation to generation and there has been a continuous stream from the first organisms to the present living organisms.

Reproduction
Heredity and variation
Evolutionary development

46. Parent material for the development of soils is formed through the physical disintegration and chemical decomposition of rock particles and organic matter.

Formation and composition of the soil

TABLE II (CONTINUED)

47. From the lower to the higher forms of life, there is an increasing complexity of structure, and this is accompanied by a progressive increase in division of labor.

Evolutionary development
Classification

48. The work of the chlorophyll of all chlorophyll-bearing plants is essential to all living things.

Photosynthesis
Interdependence of life

49. Osmosis, the diffusion of molecules of a solvent (usually water) through a semi-permeable membrane (a layer of cells or the membrane of a single cell) from the point of higher concentration of the solvent to a point of lower concentration, with a stoppage of the flow of molecules of the solute, is a basic process in plant and animal physiology.

Some biological chemistry and physics

50. The continuance of higher forms of life in anything like the present kinds and numbers would be impossible without bacteria and molds. They break down the complex carbohydrates and protein substances of dead plants and animals into simpler substances which may then be used again by living plants.

Non-green plants get food
Formation and composition of the soil
Bacteriology

51. All life comes from preceding life.

Reproduction

52. The organisms most likely to survive and reproduce are those that are structurally and physiologically best fitted to their environments.

Conflicts of life
Evolutionary development

53. Certain one-celled organisms escape adverse conditions by forming highly resistant spores which often survive

until conditions are again favorable.

Adaptations for protection

54. Every individual organism is composed of distinct hereditary characters which are transmitted by distinct hereditary factors (genes). In a hybrid the different parental genes are combined. When the sex cells of the hybrid are formed the two parental genes separate again, remaining quite unchanged and pure, each sex cell containing only one of the two genes of one pair.

Heredity and variation

55. There is a cycle, from inorganic substances in the air and soil to plant tissue, thence to animal tissue, from either of the last two stages via excretion or death and decay back to the air and soil. The energy for this everlasting rotation of life is furnished by the radiant energy of the sun.

Interdependence of life
Photosynthesis
Formation and composition of the soil

56. All living things, except chemosynthetic bacteria, depend directly or indirectly on photosynthesis for food.

Photosynthesis
Interdependence of life

57. An animal cannot live without proteins. They are necessary in cell growth and maintenance; so are necessities in the diets of animals. Plants are able to use carbohydrates and nitrates to build up the proteins necessary for growth and maintenance of their cells.

Plant nutrition
Metabolism and nutrition

58. Energy can be transformed into mass and mass into energy, but the sum total, mass plus energy, remains constant.

Some biological chemistry and physics

59. New kinds of living things have arisen through mutation.

Heredity and variation
Breeding
Evolutionary development

60. All gradations of association occur in intimate association between organisms, from those which are mutually beneficial to the individuals concerned (symbiosis) to those in which one member secures all the advantage at the expense of the other.

Interdependence of life

61. Digestion accomplishes two things; it makes food soluble in water, thus enabling the nutrients to pass through membranes and thereby reach and enter the cells; it reduces complex nutrients (fats, proteins, and carbohydrates) to simple building materials which in turn can be rebuilt into whatever living material or structural feature is necessary at the place of use.

Digestion and the digestive tract

62. Except for those organisms which exhibit metagenesis, all living things are able in one way or another to produce new living things like, or nearly like, themselves.

Reproduction

63. All plant and animal life, along with the climate and varying weather play an active part in helping to form and to change the soil.

Formation and composition of the soil

64. Carbon dioxide set free during the respiration of both plants and animals is absorbed by plants and used as a raw material of photosynthesis.

Respiration
Photosynthesis

65. There are no elements in living matter which are not found in the lifeless environment; the energy by which life is operated is the same energy by which the simplest physical and chemical transformations are brought about.

Some biological chemistry and physics

TABLE II (CONTINUED)

66. In general, living things give evidence of a definite progression from simple to complex forms.

Evolutionary development

67. Since the genes of the two parents combine at random in the germ cells and since the germ cells meet at random in fertilization, the individuals of any generation occur in certain predictable ratios.

Heredity and variation

68. The range of temperature for life activities is very narrow as compared with the range of possible temperatures. There is a minimum temperature below which and a maximum temperature above which, no life processes are carried on. The temperature range for life processes is from many degrees below 0°C to nearly the boiling point of water.

Limitations of life

69. The secretions of the endocrine glands are absorbed directly into the blood stream from the gland tissue that produces them and are absorbed from the blood by the tissues of the organs whose activities are regulated by these substances.

Hormones and glands

70. In many multicellular organisms body form is secured and maintained either by the consistency of the tissues and the internal pressure of body fluids, or by the secretion of special substances which are formed into supporting structures.

Skeleton and muscles

71. Diffusion, the spread of fluids with their dissolved substances throughout the protoplasm of a cell or the tissues of an organism is an important method of conveying oxygen from the surface of a cell to the interior, or digested foods from the place of digestion to the protoplasm that will use them, or substances that stimulate any activity to the organ that responds to them, or the waste materials from the place where they are formed to the place where they are stored or excreted.

Some biological chemistry and physics

TABLE II (CONTINUED)

72. The fundamental process of reproduction in all organisms whose cells possess nuclei is cell division which results in the precise distribution of the chromatin of the nucleus.

Reproduction

73. The hereditary characters in all organisms are determined by the genes which are carried in the chromosomes.

Reproduction and heredity

74. Decomposition of the carbon compounds of organisms provides a replenishment of carbon in the atmosphere in the form of carbon dioxide. Thus carbon is continually subjected to a series of cyclic changes from living to non-living substances.

Some biological chemistry and physics

75. All individuals of the first generation of hybrids, the F_1 generation, are uniform in appearance in alternative inheritance; only one of the two parental characters, the stronger or the dominant one is shown. In intermediate inheritance a mixture of the parental characteristics is shown.

Heredity and variation
Breeding

76. All living things, except a few anaerobes and autotrophic bacteria, secure their energy by oxidizing food.

Respiration
Metabolism and nutrition

77. Each kind of living thing has its characteristic chromosome complement, and the constancy of that complement is preserved at each cell division. Different species show the utmost diversity in number, size, and form of chromosomes.

Reproduction

78. In all organisms, increasing complexity of structure is accompanied by an increasing division of labor.

Evolutionary development

TABLE II (CONTINUED)

79. The power of contraction which results in movement is possessed by all protoplasm to a greater or lesser degree.

Protoplasm
Skeleton and muscles

80. All cells produce certain chemical compounds, secretions, which may be used in the processes going on within the cell, in the cavities adjoining the cells, or at considerable distances from the cells where they are produced.

Hormones and glands

81. Every living species is continually producing a multitude of individuals, many more than can survive, varying more or less among themselves, and all competing against each other for the available energy.

Conflicts of life

82. When the balance of nature is disturbed, disastrous results often follow.

Interdependence of life

83. Reproduction in all organisms is a process of growth in which a single cell or a group of cells is separated from the parent body and develops into a new individual.

Reproduction

84. All cells arise through the division of previous cells (or protoplasm), back to the primitive ancestral cell (or protoplasm).

Reproduction

85. Each species of living organism is adapted, or is in the process of being adapted, to live where it is found.

Adaptations and interrelations of life

86. Plants and animals are directly or indirectly dependent on the soil

Soil conservation

TABLE II (CONTINUED)

87. Anaerobic decomposition (fermentation) is accomplished at ordinary temperatures by the intervention of special enzymes, dissimilation occurs in the absence of oxygen, its final products are carbon dioxide and alcohol, and free energy is released.

Non-green plants get food
Some biological chemistry and physics
Bacteriology

88. The smallest unit of living material capable of existing independently and of maintaining itself is the unit called the cell.

The cell and cell theory

89. All the modes of reproduction of organic life are alike in their nature, varying only in complexity of development. They fall into two general categories, sexual and asexual reproduction.

Reproduction

90. All embryos start from a single fertilized egg cell and grow through division and redivision into the form of the organism which produces the egg cell.

Embryology and growth

91. Sexual reproduction is an almost universal method of reproduction and occurs in representatives of every phylum of plants and animals.

Reproduction

92. Oxygen free in the atmosphere or dissolved in water supplies the respiratory needs of practically all living organisms, except for a few parasitic and anaerobic animals, and a number of bacteria and fungi which can extract the oxygen needed for their energy production from the organic substances on which they feed.

Respiration
Bacteriology

93. The phenomena of life involve chemical change, so that wherever life processes are being carried on, chemical changes are taking place. However chemical change may

TABLE II (CONTINUED)

proceed without involving life.

Some biological chemistry and physics
Protoplasm

94. Every animal comes into the world with a certain inherited endowment of congenital behavior.

Heredity and variation

95. Growth and repair are fundamental activities of all protoplasm.

Protoplasm

96. In a living organism adaptation of action and adaptation of structure are necessary for survival.

Adaptations and interrelations of life

97. In the second and later generations of a hybrid, every possible combination appears in a definite proportion of the individuals.

Heredity and variation

98. For each disease caused by an organism a specific microbe exists.

The fight against disease

99. Heredity supplies the native capacities of an organism; environment determines to a large extent how fully these capacities will be developed.

Heredity and variation

100. Chlorophyll-bearing plants are adapted for food making.

Photosynthesis

101. All living things are continually engaged in an exacting struggle with their environments.

Conflicts of life

102. For most species of organisms the great checks on

TABLE II (CONTINUED)

increase in numbers are enemies, disease, and competition between individuals of the same species and of one species with another for food and other necessities of life.

Conflicts of life

103. The genes in the chromosomes of eggs and sperms are the physical basis of heredity.

Heredity and variation

104. The present is the key to the past; the succession of fossils in the rocks show a progressive series from simple to complex.

Evolutionary development

105. The less the amount of parental care given to the offspring the greater the need for the animal to be prolific.

Infancy and parenthood

106. The hereditary characteristics possessed by any organism depend wholly upon the genes that were transmitted to it in the reproductive cells received from its parents.

Reproduction and heredity

107. All sexually reproduced individuals begin their careers as single fertilized cells.

Reproduction

108. All living things grow by intu-susception or assimilation, making over the materials which are taken into the body into the kind of material which the body is composed of.

Metabolism and nutrition
Embryology and growth

109. A characteristic of many parasites is that they have alternate hosts.

Adaptations and interrelations of life

110. Every living organism passesses some body parts which are adapted for the life it leads.

TABLE II (CONTINUED)

Adaptations and interrelations of life

111. A characteristic of living organisms is the power of independent motion, either of protoplasm within the cell or of the body as a whole.

What is life?

112. Life depends for its primal food supply upon chlorophyll-bearing plants and for its sustained supply upon bacteria. The whole of life considered chemically is one cyclic process from chlorophyll-bearing plant to bacteria and so again to chlorophyll-bearing plant.

Photosynthesis
Bacteriology
Some biological chemistry and physics

113. From the simple to the complex organisms there is an increasingly elaborate coordination of receptivity of stimuli and response to stimuli.

Sensitivity and response

114. There is a definite size limit for each species of plant and animal.

The limitations of life

115. The genes of all organisms are subject to change, such changes producing hereditable modifications in organisms called mutations.

Heredity and variation
Breeding

116. The intelligence shown by the members of a phylum of animals usually bears a direct relation to the stage of development of the special sense organs and to the proportionate size of the brain.

The nervous system

117. The oxygen of the atmosphere is removed by animals and returned by chlorophyll-bearing plants.

Photosynthesis
Respiration

118. The environment acts upon living things, and living things act upon their environment.

Adaptations and interrelations of life

119. The chief difference in the structure of organisms from the lowest to the highest are resultant of the means adopted to perform certain functions under different exigencies imposed by the environment.

Evolutionary development

120. The fundamental life processes are the same in all organisms, but each species has other chemical processes peculiar to itself.

What is life
Protoplasm

121. Starches, fats and proteins are produced by plants and it is upon these that all animals depend primarily for food.

Plant nutrition

122. Those organisms which cannot adjust themselves to their environment lose out in the struggle for existence.

Conflicts of life

123. Stretches of water act as barriers to purely terrestrial animals, and stretches of land bar the migrations of the inhabitants of water.

Limitations of life

124. When new species are introduced into a country, few individuals or species will find themselves in the same balance as in their old home. For the majority, conditions will be unfavorable; they will fail to gain a footing and some will disappear. If the introduced species chances to be better suited, especially if it is removed from its old enemies and parasites, its numbers will increase often far beyond anything possible to it in its native country; not infrequently its abundance will force it into changed habits.

TABLE II (CONTINUED)

Adaptations and interrelations of life

125. Life is wholly confined to the surface of the planet earth and to a few miles above and below its surface (as far as our certain knowledge goes) and no one single form of life is able to span even these petty limits.

Limitations of life

126. In many organisms the number of young which are produced bears a definite relation to the chance of survival; the smaller the chance the more numerous the offspring.

Reproduction

127. Only the topsoil, with its rich organic matter, its porous structure, and its living organisms can hold the water and provide the minerals necessary to the life of the plant.

Formation and composition of the soil
Soil conservation

128. Physically all animals are fundamentally mechanisms, driven by the energy liberated in the oxidation of food.

Metabolism and nutrition
Respiration

129. True parasites secure their nourishment from the host plant or animal without exerting an injurious effect; pathogens damage the host by invading the tissues, multiplying thus and producing infection.

Non-green plants get food
Bacteriology
The fight against disease

130. Acquired characters are not inherited.

Heredity and variation

131. Variation and heredity together are responsible for the appearance and the continuation of the processes of evolution

Heredity and variation
Evolutionary development

TABLE II (CONTINUED)

132. Asexual reproduction in organisms may be brought about by fission (simple division) by external or internal budding, or by sporulation.

Reproduction

133. Fossils, dated by the rocks in which they are found, reveal portions of the actual story of life's past changes by a progression of forms from simple to complex.

Evolutionary development

134. Organisms whose fossils are found in any quantity must have lived and died in the period when the strata in which their remains are found were laid down.

Evolutionary development

135. Similar organisms are grouped together because they are believed to be related through common descent.

Evolutionary development
Classification

136. The reproduction elements and their union in fertilization are fundamentally the same in plants and animals.

Reproduction

137. The environment of living things changes continually.

Adaptations and interrelations of life

138. All animals can modify to some extent their inherent modes of reaction.

Adaptations and interrelations of life

139. As long as life continues in any organism energy is being released.

What is life?
Metabolism and nutrition

140. Life, as we know it, is dependent upon complex chemical compounds of carbon, nitrogen, hydrogen, oxygen,

TABLE II (CONTINUED)

and other elements.

Biological chemistry and physics

141. Cell division is the essential mechanism of reproduction, of heredity, and to a large extent, of organic evolution.

Reproduction
Heredity and variation
Evolutionary development

142. In organisms, the more similar the body structures and their mode of origin, and the greater the number of such structures, the closer the relationship of the organisms.

Evolutionary development
Classification

143. Much of the behavior of living animals depends on their nervous organization, and they exhibit a great variety of behavior because the nervous organization varies in complexity.

The nervous system

144. In organisms which reproduce by sexual means fertilization serves two functions; stimulating the egg to develop, and introducing the hereditary properties of the male parent.

Reproduction

145. Alternation of generations or a somewhat parallel process is characteristic of all higher plants, but is comparatively uncommon with animals.

Reproduction

146. The evolution of the earth and the living things inhabiting it has resulted from the operation of natural forces.

Evolutionary development

147. The existence of organisms depends upon their

interrelations with the environment which includes both the inorganic world and other organisms.

Adaptations and interrelations of life

148. Most living things differ from non-living things by being able to perform the control functions of irritability and spontaneous movement.

What is life?

149. The greater the similarity in structure between organisms the closer is their kinship; the less the similarity in structure, the more remote is their common ancestry.

Evolutionary development
Classification

150. Inherent reactions in animals are unlearned, independent of intelligence, and more or less inflexible in their operation; under natural conditions they are usually beneficial to the individual or the race.

Psychology and behavior

151. The carbohydrate foods made by the chloroplasts of chlorophyll-bearing plants are the original source of all energy used by plants themselves as well as that used by animals.

Photosynthesis
Plant nutrition
Metabolism and nutrition

152. All chemical processes that belong to life itself are processes that occur in solution.

Biological chemistry and physics

153. The size of cells bears no constant relation to the size of the animals or plants in which they are found.

The cell and cell theory

154. Meiosis or "chromosome reduction" from the diploid to the haploid number occurs at some stage in all organisms in which sexual processes take place, and when followed by the

return to the diploid number of chromosomes at fertilization it keeps the number of chromosomes constant for the species.

Reproduction

155. The respiratory process of both plants and animals involves exactly the same gaseous exchange and accomplishes the same function, the release of energy.

Respiration

156. If two or more groups of organisms have similar homologous structures they have descended from similar ancestors or from the same common ancestor.

Evolutionary development

157. The most primitive method of reproduction employed by organisms is the splitting of the whole body into two halves, each of which grows into a complete new individual.

Reproduction

158. The existing forms of life on the earth are not all the forms of life which have existed; there has been a great variety of animals and plants which have passed away

Evolutionary development

159. Species not fitted to the conditions about them do not thrive and finally become extinct.

Conflicts of life
Evolutionary development

160. Protoplasm is built only by protoplasm and every cell comes from a cell.

Protoplasm
Reproduction

161. The forms of living things have changed slowly but steadily in the past.

Evolutionary development

162. Each species of animal or plant tends to extend its

TABLE II (CONTINUED)

range until some impassible barrier is encountered.

Limitations of life

163. Life may exist under conditions of light from bright sunlight to the complete darkness of caves.

Adaptations and interrelations of life

164. Viruses require living cells for their growth and they multiply only within living cells.

The fight against disease

165. In most cases, a character is not determined by a single gene, but by the interplay of two or more genes; in this interaction the genes may interfere with, modify, counteract, or reinforce each other.

Reproduction

166. Living organisms, during the growth period, increase the mass of the cell from within through the ingestion and utilization of food substances. When the cell reaches a maximum size mitosis usually results.

The cell and cell theory
Embryology and growth

167. An organism must have certain materials for its life processes and each organism must secure the required materials that it cannot build for itself.

Metabolism and nutrition
Interdependence of life

168. At every stage of development the individual is an integrated organism; all of its cells, tissues and organs are correlated and act together as a unit.

The unity of a living organism

169. All cells within one multicellular individual, except the gametes in animals and the spores in plants, are characterized by the same chromosomal content, as they all originated by cell division from a common cell.

The cell and cell theory

TABLE II (CONTINUED)

170. Throughout the plant and animal kingdoms there is a general preference for cross-fertilization; an avoidance of the union of eggs with male elements from the same individual. In those animals and in the great majority of plants which are hermaphrodite, there are usually precautions to restrain self-fertilization.

Reproduction

171. Living things reproduce offspring which possess the genes of their ancestors though these offspring do not necessarily resemble any one of these ancestors.

Heredity and variation

172. Living organisms cannot live in the upper levels of the atmosphere because of deficiency of oxygen for respiration, deficiency of pressure upon the exterior of the body, and intense cold.

Limitations of life

173. The fundamental function of the germ-plasm is the perpetuation of the species; the body or soma-plasm serves as the vehicle for the germ-plasm.

Reproduction

174. Species can and do become extinct, but they usually live on for ages in spite of the death of individuals.

Evolutionary development

175. Animals resemble each other more and more the farther back we pursue them in embryological development.

Embryology and growth

176. The bodies of most animals exhibit bilateral symmetry which is an adaptation for forward motion.

Adaptations and interrelations of life

177. The genes in the chromosomes of the egg and the sperm are the carriers of the structural characters of the parents to the next generation.

Heredity and variation

TABLE II (CONTINUED)

178. In plants and animals organs of the same structural plan are often applied to the most diverse functions.

Adaptations and interrelations of life
Evolutionary development

179. In all organisms, the higher the organization the greater the degree of differentiation and division of labor and of the dependency of one part upon another.

The unity of a living organism

180. New types of organisms, different enough to be regarded as new species, may spring fully formed from a cross.

Breeding

181. All the energy used by chlorophyll-bearing plants in their secondary building processes comes from compounds formed in photosynthesis.

Photosynthesis.
Plant nutrition

182. The ability and necessity of members of a species to produce other individuals like themselves is essential for the welfare and maintenance of the species, since no living thing can maintain itself for an unlimited period of time.

Reproduction

183. Every influence exercised by micro-organisms upon man and his environment whether beneficial or detrimental, is the result of a chemical change in the substances from which they secure their nutrition or of a chemical product synthesized from them.

Non-green plants get food
The fight against disease
Bacteriology

184. Energy changes accompany all chemical changes in living organisms and every chemical change has physical concomitants.

Biological chemistry and physics

TABLE II (CONTINUED)

185. Every cell originated from a cell and every chromosome from a chromosome.

Reproduction

186. In general, the natural flora and fauna of a region is the most luxuriant that it can support.

Limitations of life
The soil and conservation

187. The forms of all chlorophyll-bearing plants are adapted for carrying on photosynthesis.

Photosynthesis
Plant structure and stems

188. Evolution has needed enormous lapses of time for its operations.

Evolutionary development

189. Life exists from the depths of the ocean to the mountain hights.

Limitations of life

190. Plants and animals in the course of their generations are changed and molded to meet the requirements of their existence, and the individuals and types best adapted to their life situations are the ones that survive.

Evolutionary development

191. The parasite-host relationship is usually specific and requires not only marked adaptation of the parasite but often also an adjustment on the part of the host.

Non-green plants get food
Bacteriology

192. The nucleus of a cell always contains a complex of protein materials, chromatin, the specialized vehicle which transmits hereditary characters in organisms.

Heredity

193. The number of chromosomes in the somatic cells of all the individuals of a species is a constant; except in chimeras, gynandromorphs, etc.

Heredity and variation

194. One of the most "constant" features of natural phenomena is variability, but variability is always within definite limits.

Heredity and variation

195. Each formation of sedimentary rock has its peculiar assemblage of fossils and there is a definite relation between the fossils found in rocks and the position of these rocks in the geologic time-table.

Evolutionary development

196. Living things, even of the same kind, are never exactly alike, not even with regard to single traits (characteristics) such as color or shape.

Heredity and variation

197. The distinctive properties of organisms depend upon the complexity of the molecular organization of protoplasm, the one essential constituent of every living thing.

Protoplasm

198. Genes that lie in the same chromosome tend to remain together in reduction so that the characters which they determine are linked in inheritance.

Heredity and variation

199. For most species of organisms periods of great scarcity of individuals alternate with waves of great abundance, and the peaks of the waves succeed each other in a regular cycle.

Conflicts of life

200. Discontinuous widespread distribution is characteristic of old groups of animals and means that they formerly occupied also much of the intervening space.

TABLE II (CONTINUED)

Evolutionary development

201. The bodies of most animals exhibit some degree of symmetry, either spherical, radial, or bilateral.

Adaptations and interrelations of life

202. The separation of homologous chromosomes at reduction division in the germ cell is a matter of chance, the separation in any one pair occurs absolutely without reference to what had occurred in any other pair in the cell.

Heredity and variation

203. During the process of maturation in an egg or a sperm corresponding maternal and paternal chromosomes with their genes, go to different cells in the reduction division so that each secondary oocyte or spermatocyte receives one, but not both, of these chromosomes with its genes.

Heredity and variation

204. The physical and chemical properties of plant and animal protoplasm are similar.

Protoplasm

205. The history of organisms shows that evolution and race divergence has been the result of mutations.

Evolutionary development

206. All plants, and a few simple animals are able to recombine nitrogenous by-products of respiration into proteins by re-synthesizing them anew with carbohydrate molecules.

Plant nutrition

207. Fossilization is the fate of very few animals and plants. The great majority of dead things simply decay and disappear and then material from them is returned to the general circulation of nature to be built up into the bodies of new organisms.

Formation and composition of the soil

TABLE II (CONTINUED)

Biological chemistry and physics
Evolutionary development

208. The life history of the individual tends to recapitulate the history of the race.

Evolutionary development
Embryology and growth

209. Sexual union in plants and animals affords a method of variation due to the mixing of different protoplasms.

Heredity and variation

210. Carbon and nitrogen are the basic elements in the protoplasmic compounds.

Biological chemistry and physics

211. All living things die, but life continues from age to age.

What is life?
Reproduction

212. Inbreeding in animals or plants results in a uniform strain.

Heredity and variation
Breeding

213. Plants and animals utilize similar food substances but they are obtained in different ways.

Food getting adaptations

214. The more highly specialized an organism is the more likely it is to become extinct if its environment changes.

Evolutionary development

215. Animals of diverse origin living among similar surroundings tend to become, at least superficially, alike and they often develop parts that have the same function.

Adaptations and interrelations of life
Evolutionary development

TABLE II (CONTINUED)

216. In a cross of the F_2 generation of hybrids the genes which determine the characters are segregated in the gametes so that a certain percent of the offspring possess the dominant character alone, a certain percent the recessive character alone, while a certain percent are again hybrid in nature.

Heredity and variation

217. Similarities in the embryological development of organisms show hereditary relationships between these organisms and the closer two species are related the longer they parallel one another in development.

Embryology and growth

218. In the maturation of the sex cells at the pairing of the chromosomes, except for the single sex chromosomes in some organisms, the two members of each pair come originally one from the paternal line and one from the maternal line.

Reproduction and heredity

219. Sex is inherited; it follows a given distribution of the chromosomes according to definite Mendelian ratios.

Heredity and variation

220. In cells the fundamental processes of food intake, digestion, regeneration of lost structures and survival are controlled by the nucleus.

The cell and cell theory

221. The older layers of rocks contain forms which are extremely unlike the now living animals and plants, while the more recent layers contain types more similar to our contemporary ones.

Evolutionary development

222. The fact of primary importance in the history of life displayed by the geological periods is the orderly succession of living forms.

Evolutionary development

223. The members of any species depend, on the one hand,

TABLE II (CONTINUED)

upon its rate of reproduction and growth, and on the other, upon its death-rate from accident, enemies and disease.

Conflicts of life

224. Evolutionary relationships in organisms are formulated on the basis of structural similarity.

Evolutionary development.

225. Most of the species of modern animals are of relatively recent origin; having evolved from others in the past and probably continuing to evolve into other species of animals.

Evolutionary development

226. Isolation of a piece of land or a body of water from the rest of the world always permits its animal and plant inhabitants to evolve along their own peculiar lines and each race involved tends to become more uniform.

Evolutionary development

227. Growth and development in organisms is essentially a cellular phenomenon, a direct result of mitotic cell division, and it is always controlled by the axiate organization of the cell.

The cell and cell theory
Embryology and growth

228. Some of the differences between related groups and organisms separated by a geographical barrier are due to adaptive responses to slightly different environmental factors.

Evolutionary development

229. The power of living things to change is definitely restricted, specialization reaches the limit of efficency prescribed by mechanical or chemical laws.

Adaptations and interrelations of life

230. In animals certain waste products as well as vitamin and endocrine substances exert regulatory effects on the activities of various organs in the body.

TABLE II (CONTINUED)

The unity of a living organism

231. Mutations occur independently of the activities of individuals as more or less haphazard hereditary variations.

Heredity and variation

232. When anabolism exceeds catabolism as it does in all young animals growth is inevitable.

Embryology and growth
Metabolism and nutrition

233. The action of "organizers" (probably chemical in character) produced in the developing embryo causes the developing egg, which at first acts as a whole, to produce specialized parts which develop independently.

Embryology and growth

234. The amount of oxygen taken into the body of an organism and absorbed by the cells is derectly proportional to the amount of energy released in the body.

Metabolism and nutrition
Respiration

235. The energy of solar radiation is continually working changes in the surface of the earth and the atmosphere surrounding the earth; all life on the earth is affected directly or indirectly by these changes.

Adaptations and interrelations of life

236. Cells within an organism are dependent upon their environment as well as their genes, in the process of becoming what they finally become.

Heredity and variation

237. New types of living things arise through variations in previously existing kinds.

Heredity and variation
Evolutionary development

TABLE II (CONTINUED)

238. The most primitive and simplest forms of life exist in the oldest rocks, and organisms found in younger and younger rocks represent higher and higher forms.

Evolutionary development

239. Commensalism usually evolves, not in the direction of mutualism, but towards parasitism.

Interdependence of life

240. The nature of the response made by a cell to a stimulus is determined by the nature of the responding protoplasm, as well as by the kind of stimulus.

Sensitivity and response

241. The distribution of any group of land animals will depend upon three factors: first, on the region where the group happened to originate; second, upon the connections which this region then and later happened to have with other land masses; and third, upon the fate of the group in the different regions to which it obtained access.

Evolutionary development

242. Change in the numbers of organisms in communities may be rapid even though the environmental conditions apparently alter slowly and gradually.

Adaptations and interrelations of life

243. In organisms inhabiting similar environments evolution has often produced convergence, the molding of unrelated stocks into similar forms by the needs of their way of life.

Evolutionary development

244. In higher plants and in the higher air-breathing vertebrates a progressive emancipation from life in water and an adaptation to life on dry land is traceable.

Evolutionary development.

245. In plants the gamete-bearing phase of the life cycle is haploid; the spore vearing phase is diploid, the reduction division occurs during spore formation.

TABLE II (CONTINUED)

Reproduction

246. Analogous structures in plants and animals serve to carry on similar functions but are not similar in basic plan or mode of origin.

Adaptations and interrelations of life
Evolutionary development

247. Similarity between organisms suggests common ancestry; the nature of the differences between them indicates which is the more primitive type.

Evolutionary development

248. The earth's position in relation to the sun is a determining factor of life on the earth.

Limitations of life

249. Fluctuating variations found within a pure line are not inherited, and cannot change the character of the offspring permanently.

Heredity and variation

250. The present variety in living forms has resulted from the modification through long periods of time of simpler and less varied ancestral types, and by degeneration in many groups of organisms from more complex organisms.

Evolutionary development

251. The first forms of life were altogether independent, but evolution has resulted in the general interdependence of organisms.

Interdependence of life

252. The heredity of an individual organism produced by sexual means is determined by what occurs to the chromosomes in the reduction division in maturation and in fertilization.

Heredity and variation

253. Reversion occurs only when different varieties of of plants or animals are crossed, never in genetically

TABLE II (CONTINUED)

pure stock.

Heredity and variation
Breeding

254. The greater the distance two genes lie apart in the chromosome the more often they separate and cross over when a chromosome fragments and part of it adheres to another chromosome.

Heredity and variation

255. The colloidal nature of the cell material as a whole furnishes the basis of some of the fundamental life processes.

Protoplasm

256. In cells a quantitative gradient in metabolic rate runs from the apical to the basal pole of the cell, and the various formed components of the cell are arranged in definite relation to the gradient.

The cell and cell theory

257. Hybridization gives variation, isolation gives fixation, and fixation gives speciation.

Heredity and variation
Breeding

258. As nature progressed in the production of new forms, new potentialities were also added.

Evolutionary development

259. In polyhybrid crossings (F_2 individuals with two or more pairs of hereditary characters) all possible combinations of the parental characters are shown in characteristic ratios.

Heredity and variation

260. In fossilization, it is usually the hard parts of organisms that are preserved.

Evolutionary development

261. In fertilization in most bisexual organisms, the egg contributes half the specific number of chromosomes to the zygote as does also the sperm.

Reproduction
Heredity and variation

262. All individuals of a unicellular species, except a sexual species, contain the same or "similar sets" of chromosomes.

Heredity and variation

263. In most organisms, large size is accompanied by tissue differentiation and special organs for different kinds of work.

Adaptations and interrelations of life

264. There are no living chemical compounds; life is a property of the coordinated association of the different organic and inorganic substances which make up protoplasm.

What is life?
Protoplasm

265. Turgor in cells is maintained by osmotic pressure; cell membranes are semi-permeable with respect to water and the substances dissolved in it, and the concentration of salts is higher within the cell than outside, the entrance of water into the cell is accomplished mainly by osmosis.

Biological chemistry and physics

266. Offspring produced asexually are almost always like the parent; they will have exactly the same chromosomes and the same gene complex.

Heredity and variation

267. In the vast majority of organisms it is the male who has the unsymmetrical chromosome complement, and the sperms therefore are the decisive begettors either of males or of females.

Heredity and variation

TABLE II (CONTINUED)

268. In the water, free swimming organisms are very light because their specific gravity is only slightly greater than that of the medium in which they live.

Adaptations and interrelations of life

269. In photosynthesis, the energy of sunlight is used to lift the carbon to an energy level from which, as it descends, it furnishes the energy for the building of many compounds and for the carrying on of life processes.

Photosynthesis

270. Adult organisms that differ greatly from one another but which show fundamental similarities in embryological development have originated from similar ancestors.

Evolutionary development
Embryology and growth

271. None of the materials present in living protoplasm leave it when death ensues, for a given bit of protoplasm weighs exactly the same after death as when alive.

What is life?
Protoplasm

272. The smaller an organism, the greater is the proportion of its surface to its weight, since surface increases as the square of its length, weight as its cube.

Biological chemistry and physics

273. No relation exists between the common origin of chromosomes from the same gamete and their later distribution during chromosome reduction. Chance alone seems to determine how the chromosomes are distributed.

Heredity and variation

274. New species of plants and animals appear at some definite point on the earth and then spread out from that location as a center.

Limitations of life

275. The nutritional processes of different classes of

TABLE II (CONTINUED)

organisms supplement each other in such a manner that they result in a nutritional balance among living things.

Adaptations and interrelations of life

276. It is indispensable to successful parasitic existence that the symbiotic relationship be so adjusted that means are provided for the escape of the parasites or their offspring in order that new generations in new hosts may obtain.

Interdependence of life
Non-green plants get food

277. An adaptive character may give its possessors a definite advantage over other members of the species, and so in the course of generations, due to the elimination of the non-possessors of this character, and of the conferring of this character upon others by heredity become a character of all the members of the species.

Evolutionary development

278. The sex chromosome may carry the genes for a number of characters other than sex. Such characters are sex linked.

Heredity and variation

279. Throughout the organic world there is a cyclic relation between death and the continuance of organic life.

Limitations of life
Reproduction

280. The orderliness of the life processes of an organism is not an isolated orderliness, but one aspect of the orderliness of the universe.

Biological chemistry and physics

281. Many hereditary characters are subject to non-genetic or environmental variation in expression.

Heredity and variation

282. When a large thickness of rocks shows every evidence of having been laid down steadily and continuously, year

TABLE II (CONTINUED)

after year, it may well change its character. If it changes its character, the character of the animals and plants which live on it will change too.

Adaptations and interrelations of life

283. All heritable variations which are not the result of recombinations of genes are mutations, which are changes in genes, in some cases induced by environmental agents.

Heredity and variation

284. Organisms which have no means of reproduction other than asexual show very little variation.

Heredity and variation

285. All cells contain autolytic enzymes that at death are capable of producing digestive changes which result in the final disintegration of the body.

The cell and cell theory

286. The difference in motion and location between animals and plants is one of degree.

Adaptations and interrelations of life

287. Many of the processes of change in the universe are rhythmic, or periodic, and life processes constitute no exception to the rule.

Biological chemistry and physics

288. Animals and plants lacking some means of mechanical support are debarred from terrestrial life.

Adaptations and interrelations of life

289. Individuality in an organism is maintained throughout life in spite of the fact that the actual chemical constitution of the living substances composing it is constantly changing.

What is life?
Protoplasm

TABLE II (CONTINUED)

290. The crises of evolution when they occur are not crises of variation but of selection and elimination; not strange births but selective massacres. The germ plasm has gone on throwing up mutations at about the same rate age after age.

Evolutionary development

291. Most regions that are surrounded by barriers are devoid of a very great variety of species of animals or plants. However, the larger the area isolated the greater the variety of forms.

Limitations of life

292. Water living organisms do not merely dilute their weight but counteract it by accumulating lighter substances inside themselves.

Adaptations and interrelations of life

293. During the main evolution of any stock, for each type of organism that lives on to be ancestral to the next evolutionary phase, there are considerable numbers thrown off to live a few tens of thousands of years and die without descendants.

Evolutionary development

294. Many of the rhythmic changes of protoplasm such as ciliary action, heartbeat, and rhythmic processes in cell division are based upon reversible changes in the colloidal state.

Protoplasm
The cell and cell theory
Biological chemistry and physics

295. Any hereditary change that follows the laws of Mendelian heredity is due to a gene mutation.

Heredity and variation

296. In plants and animals subject to parthenogenetic development (development from unfertilized germinal cells) reduction of chromosomes does not occur.

Reproduction

TABLE II (CONCLUDED)

297. In general, the extent of a response is rather definitely fixed for a given cell. If a cell responds at all, it does so to its full capacity.

The cell and cell theory

298. Life and protoplasm in a cell will remain indissolubly associated for an indefinite period of time unless the cell suffers an accident, or becomes diseased, or is unable to throw off the toxic waste substances that accumulate with age as a result of normal metabolism.

The cell and cell theory
Protoplasm
What is life?

299. The greater the period that has elapsed since two stocks diverged, the greater the difference in the terminal products.

Evolutionary development

300. The embryos of different animals, in addition to being more like each other as development is traced backward; show also a widening contrast with their parents and their adult destiny.

Embryology and growth

Findings. Three hundred ninety-seven assignments of 39 different subject-matter topics were defensibly made to 300 biological principles and were, therefore, deemed to be suitable for use to develop an understanding of the principles. At least one topic was assigned to each of the 300 principles. One principle had only 6 topics assigned to it; 15 each had only 3 topics; 58 each had only 2 topics; and the remaining 226 of the 300 principles each had only 1 topic.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Statement of the Problem

The purpose of the investigation is (1) to compile a composite outline of the subject-matter topics found in five textbooks of biology for high school, and (2) to assign to biological principles those topics which a study of should contribute to the development of an understanding of the principles.

Method Used

In the first part of the investigation, the subject-matter topics (chapter, center, and paragraph headings) from five high-school textbooks of biology were arranged in a composite outline. This was accomplished by first making separate outlines containing all the topics from each book, and then consolidating the five outlines into one which contained all topics from all five books. The resultant composite outline was then submitted to a jury of three subject-matter specialists in the field of biology for validation. This list is reproduced in Table I of this report.

In the second part of the investigation, the major topics in the composite outline were assigned to

biological principles. Those topics which, in the investigator's opinion, might be reasonably expected to contribute to the understanding of a principle were assigned to that principle. The assignments of topics to principles were validated by submission to a jury of three specialists in the field of biology. The list of principles followed by the topics which were assigned to them is reproduced as Table II of this report.

Summary of Findings

In the five textbooks, 2,078 subject-matter topics were found. Of 73 major topics as found in all of the books analyzed, 38, or 52 percent, were present in each of the five textbooks. In the second part of the investigation, 38 different subject-matter topics (not the same 38 as above) of the 73 major topics were given 397 assignments to 300 biological principles. At least one topic was assigned to each of the 300 principles. Two hundred twenty-six of the 300 principles were each assigned only one topic; 58 principles only 2 topics; 15 only 3; and 1 only 6.

BIBLIOGRAPHY

Bayles, Ernest E. and Burnett, R. Will, Biology for Better Living. New York: Silver Burdett Company, 1941. Pp. XIV + 754.

Benedict, Ralph C., Knox, Warren W., and Stone, George K., Life Science. Boston: MacMillan Company, 1941. Pp. XIV + 682.

Bergman, George J., "Entomology and General Education", Science Education, XXXI, (February, 1947), 23-32.

Blanchet, Waldo Emerson. A Basis for the Selection of Course Content for Survey Courses in the Natural Sciences, Unpublished Doctor's dissertation, University of Michigan, 1946. Pp. VII + 476.

Clemenson, Jessie W., "Vitalized High School Science Through the Learning Process," Science Education, XIX, (April, 1935), 51-55.

Curtis, Francis D. Second Digest of Investigations in the Teaching of Science. Philadelphia: P. Blakiston's Son and Company, 1931. Pp. XX + 424.

Curtis, Francis D., Third Digest of Investigations in the Teaching of Science. Philadelphia: The Blakiston Company, 1939. Pp. XVII + 419.

Downing, Elliot Rowland, An Introduction to the Teaching of Science. Chicago: The University of Chicago Press, 1934. Pp. II + 248.

Gruenberg, Benjamin C. and Bingham, N. Eldred, Biology and Man. Boston: Ginn and Company, 1944. Pp. VIII + 719.

Hackett, Glenn L. An Analysis in Terms of Generalizations of Ten Biologies Used in High Schools. Unpublished Master's thesis, University of Chicago, 1927.

Heinemann, Ailse M., "A Study of General Science Textbooks," General Science Quarterly, XIII, (November, 1928), 11-23.

Hunter, George W., Science Teaching, New York: American Book Company, 1934. Pp. VIII + 552.

Irish, E. Eugene. An Analysis of the Objectives of High School Biology as Determined by the Study of Textbooks, Courses of Study, and Periodical Literature. Unpublished Master's thesis, University of Michigan, 1946. Pp. IV + 52.

Jones, Ruth V. A Study of the Principles of Science Found in Ninth-Grade Textbooks of General Science. Unpublished Master's thesis, University of Michigan, 1946. Pp. III + 59.

Martin, William Edgar. A Determination of the Principles of the Biological Sciences of Importance for General Education, Unpublished Doctor's dissertation, University of Michigan, 1944. Pp. VII + 386.

Martin, W. Edgar, "A Determination of the Principles of the Biological Sciences of Importance for General Education," Science Education, XXIX, (February, 1945), 45-58; XXIX (March, 1945), 100-105; XXIX, (April-May, 1945), 158-163.

Martin, W. Edgar, "A Chronological Survey of Published Research Studies Relating to Biological Materials in Newspapers and Magazines," School Science and Mathematics, XLV (June, 1945), 543-550.

McKibbon, Margaret, "Objectives in the Teaching of Biology," The American Biology Teacher, IX (January, 1947), 119-120.

Menzies, Jessie A. An Analysis of the Generalizations and Applications in Ten College Textbooks in Biology, Unpublished Master's thesis, University of Chicago, 1927.

Monroe, Walter S., and Weber, Oscar F., The High School. New York: Doubleday Doran and Company, 1928. Pp. VIII + 511.

Moyer, Harold E. The Determination of the Relative Importance of Biological Principles as Shown by Applicatory Activities. Unpublished Master's thesis, Colorado State College of Education, 1936. Pp. I + 56.

National Society for the Study of Education, A Program for Teaching Science, Thirty-First Yearbook, Part I. Bloomington, Illinois: Public School Publishing Company, 1932. Pp. XII + 364.

Nelson, James F., Problems, Generalizations and Concepts Basic to a Secondary Science Program. Unpublished Master's thesis, Colorado State Teacher's College, 1935. Pp. IX + 169.

Olds, C. Raymond, The Principles of Biology for Secondary School Instruction. Unpublished Master's thesis, Colorado State College of Education, 1936.

Progressive Education Association, Commission on Secondary-School Curriculum, Science in General Education. New York: D. Appleton-Century Company, 1938. Pp. XIII + 591.

Powers, Samual Ralph, "Interpretative Generalizations as Aids in Curriculum Work in Science," Science Education, XX (December, 1936), 221-222.

Pruitt, Clarence Martin. An Analysis, Evaluation, and Synthesis of Subject-Matter Concepts and Generalizations in Chemistry, Doctor's dissertation, Teacher's College, Columbia University, 1935.

Ritchie, John W. Biology and Human Affairs. Yonkers, N.Y. World Book Company, 1941. Pp. XIV + 1026.

Vance, B.B., and Miller, D.F., Biology for You, Chicago: J.B. Lippincott Company, 1946.

Wise, Harold E. A Determination of the Relative Importance of Principles of Physical Science for General Education. Unpublished Doctor's dissertation, University of Michigan, 1941. Pp. IV + 767.

Wise, Harold E., "A Determination of the Relative Importance of Principles of Physical Science for General Education," Science Education, XXV (December, 1941) 371-379; XXVI, (January, 1942), 8-12.

Wise, Harold E., "A Synthesis of the Results of Twelve Curricular Studies in the Field of Science Education," XXVII, (February, 1943), 34-40; XXVII, (September-October, 1943), 67-76.

Zeigler, Robert T., "A Study of Fact Retention in General Science," Science Education, XXVI (February, 1943), 83-84.

APPENDIX

A LIST OF THE TOPICS WHICH COULD NOT BE ASSIGNED BY THE INVESTIGATOR TO A BIOLOGICAL PRINCIPLE

Science of Biology - living things
  Biology - study of life
  Builders of biology
  Science - to obtain and test knowledge
Uses of Biology
  Pleasure and profit from biology
  Biology a preparation for vocations
Springtime biology
  Bird activities
  Water activities
  Insects of spring
  Freshwater plants of springtime
  Spring flowers
Plants and plant activities
  Historical notes
  Plant roots
  Weeds - nuisance plants
  Seeds in industry
The soil and conservation
  Control of pests
  Wildlife conservation
Mechanics of biology
Reproduction and heredity
  Human inheritance
Body systems and functions
  The integument
Behavior, sensitivity and response
Health and sickness
  Health on a national scale
  First aid
  Health a personal matter
  General, plant and animal
  Plants
  Animals

BOSTON UNIVERSITY
1 1719 02551 5182

CORRESS BINDER
BF 250-P7 EMB
MADE BY
CO PRODUCTS, INC.
OGDENSBURG, N. Y.